

Oznaka poročila: ARRS-RPROJ-ZP-2015/227



## ZAKLJUČNO POROČILO RAZISKOVALNEGA PROJEKTA

## A. PODATKI O RAZISKOVALNEM PROJEKTU

## 1. Osnovni podatki o raziskovalnem projektu

<b>Šifra projekta</b>	N1-0011	
<b>Naslov projekta</b>	GReGAS - Geometrijske reprezentacije in simetrije grafov, preslikav in drugih diskretnih struktur ter aplikacij v znanosti	
<b>Vodja projekta</b>	1941	Tomaž Pisanski
<b>Tip projekta</b>	N	Projekti ESF in ERC
<b>Obseg raziskovalnih ur</b>	18137	
<b>Cenovni razred</b>	B	
<b>Trajanje projekta</b>	07.2011 - 06.2014	
<b>Nosilna raziskovalna organizacija</b>	1669	Univerza na Primorskem, Inštitut Andrej Marušič
<b>Raziskovalne organizacije - soizvajalke</b>	588	Univerza v Ljubljani, Pedagoška fakulteta
	1554	Univerza v Ljubljani, Fakulteta za matematiko in fiziko
	2547	Univerza v Mariboru, Fakulteta za naravoslovje in matematiko
	2975	ABELIUM d.o.o., raziskave in razvoj
<b>Raziskovalno področje po šifrantu ARRS</b>	1	NARAVOSLOVJE
	1.01	Matematika
<b>Družbeno-ekonomski cilj</b>	13.01	Naravoslovne vede - RiR financiran iz drugih virov (ne iz SUF)
<b>Raziskovalno področje po šifrantu FOS</b>	1	Naravoslovne vede
	1.01	Matematika

## B. REZULTATI IN DOSEŽKI RAZISKOVALNEGA PROJEKTA

2. Povzetek raziskovalnega projekta<sup>1</sup>

SLO

Geometrične in druge reprezentacije grafov in kombinatoričnih struktur, ki temeljijo na grafih imajo pomembne aplikacije v matematiki, računalništvu, socialnih omrežjih, kemiji, bioinformatiki, itd. Ob črpanju motivacije iz aplikacij je bil glavni cilj projekta, da skupaj s

partnerji v EU razvijemo koherentno teorijo reprezentacij grafov s poudarkom na simetričnih in skoraj simetričnih strukturah oz. produktih. Projekt sestavlja pet tem.

**Tema 1: Reprezentacije in struktura grafov in drugih diskretnih struktur.** Preučevali smo splošne vidike reprezentacij grafov z uporabo strukturnih lastnosti in informacije o simetriji in s tem prispevali k izgradnji teorije reprezentacij (enotski grafi, reprezentacije, krovi, itd.)

**Tema 2: Skoraj simetrične strukture in produkti.** Študirali smo izbrane teme povezane z grafovskimi produkti posebnih družin grafov (grafi Sierpinskega, Fibonaccijeve kocke) s poudarkom na izbranih grafovskih invariantah, še posebej v povezavi s Wienerjevim indeksom.

**Tema 3: Reprezentacije simetričnih grafov.** Z nadaljevanjem razvoja teorije točkovno-transitivnih grafov smo prispevali k boljšemu razumevanju, še posebej v povezavi z določenimi strukturnimi lastnosti grup avtomorfizmov grafov v kontekstu grafovskih reprezentacij simetričnih kombinatoričnih struktur. Posebno pozornost smo posvetili opisu kubičnih in 4-valentnih grafov, na katerih delujejo grupe ločno tranzitivno, ter klasifikaciji posebnih struktur iz katerih izvirajo zanimive (delne) geometrije (asociacijske sheme, krepko regularni grafi, kletke).

**Tema 4: Reprezentacije konfiguracij, zemljevidov in politopov.** Raziskave so bile osredotočene na strukturne lastnosti, klasifikacijo in oštevilčenje konfiguracij, zemljevidov in politopov v povezavi z njihovimi kombinatoričnimi in geometričnimi reprezentacijami. Prav tako smo se osredotočali na razvoj ustreznih algoritmov. Preučevali smo reprezentacije konfiguracij preko grafov in obratno, konstrukcije. Prav tako smo se osredotočili na klasifikacije novih razredov simetričnih konfiguracij z visoko stopnjo povezanosti.

**Tema 5: Reprezentacije velikih omrežij in aplikacije v kemiji, bioinformatiki in socialnih omrežjih.** Velika omrežja z večimi milioni vozlišč so običajno redka in pri njihovi obravnavi se soočamo z določenimi tehnološkimi omejitvami (v celoti morajo biti shranjena v spominu). V projektu smo se osredotočili na omrežja citiranj, dvodelna omrežja in dinamična omrežja (analiza in vizualizacija). Identificirali in predstavili smo več možnosti aplikacij teorije grafov in zemljevidov v kemiji in sintetični biologiji.

Rezultati projekta so objavljeni v več kot 40 člankih v znanstvenih revijah z impact faktorjem.

Poročilo predstavlja le del projekta GReGAS v okviru sheme EUROCORES/EUROGIGA s strani Evropske znanstvene fundacije, ki smo ga izvajali v Sloveniji.

ANG

Geometric and other representations of graphs and graph based combinatorial structures have important applications in mathematics, computer science, social networks, chemistry, bioinformatics, etc. Motivated by applications, the main goal of the project was to, together with EU partners, develop a coherent theory of graph representations with emphasis on symmetric and near symmetric structures or products. The project consists of 5 themes.

**Theme 1: Representations and structure of graphs and other discrete structures.** General aspects of graph representations using graph structural properties and information on symmetries have been studied, thus making the contribution towards building coherent representation theory (unit distance graphs, representation, covers, etc.)

**Theme 2: Near symmetric structures or products.** Special topics related to graph products and special families of graphs were studied (Sierpinski graphs, Fibonacci cubes) together with particular graph invariants, especially Wiener index.

**Theme 3: Representations of symmetric graphs.** By further developing theory of vertex-transitive graphs we have contributed to better understanding, especially of certain structural properties of automorphism groups of graphs in the context of graph representations of highly symmetric combinatorial structures. Special attention was given to description of cubic and quartic graphs admitting arc-transitive group actions and classification of special structures from which interesting (partial) geometries arise (association schemes, strongly regular graphs, cages).

**Theme 4: Representations of configurations, maps and polytopes.** The research focused on structural properties, classification and enumeration of configurations, maps and polytopes relevant for their combinatorial and geometric representations, as well as on development of relevant algorithms. Relations between geometry and symmetries were studied in various geometries, both for finite and infinite structures. We have investigated representing configurations via graphs and vice versa, and studied construction and classification of new classes of symmetric highly incident configurations.

**Theme 5: Representations of large networks and applications in chemistry, bioinformatics and social networks.**

Large networks have several millions of vertices, are usually sparse and their use imposes certain technological limits (a need to store them completely in the computer memory). In the project, special attention was given to citation networks, two-mode networks and dynamic networks (analysis and visualization). Several applications of map and graph theory have been introduced to chemical graph theory and synthetic biology.

The results of the project were published in more than 40 publications in journals with impact factor.

The report presents only the part of the EUROCORES/EUROGIGA project GReGAS selected by European Science Foundation, which was carried out in Slovenia.

### 3. Poročilo o realizaciji predloženega programa dela na raziskovalnem projektu<sup>2</sup>

Projekt se je začel z julijem 2011 s t.i. "kick-off" sestankom v Parizu, kjer so se zbrali vodje vseh 4 projektov v programu EUROGIGA/EUROCORES in je bil določen program za aktivnosti mreženja. Slovenski del projekta je tako v okviru projekta organiziral naslednje mrežne aktivnosti:

- simpozij CSASC 2011 v Kremsu, Avstrija, 2011
- SODO 2012 v Novi Zelandiji,
- konferenco Computers in Scientific Discovery 6, 2013, Koper, Slovenija,
- simpozij CSASC 2013 v Kopru, Slovenija,
- GEMS 2013 na Slovaškem,

Poleg tega pa se iz teh sredstev organizira tudi ravno tekoča konferenca EuroCD 2015 v Ljubljani, Slovenia (marec 2015).

Projekt je naslavljal pet tem, ki so navedene v nadaljevanju z opisom rezultatov.

#### 1. Reprezentacije in strukture grafov in drugih diskretnih struktur

Preučevali smo grafe z enotsko razdaljo, t.j. take, ki jih lahko predstavimo v ravnini tako, da imajo vse povezave enako dolžino [COBISS.SI-ID 16312665]. Za pomembno družino grafov, to so posplošeni Petersenovi grafi, smo pokazali, da so grafi z enotsko razdaljo [COBISS.SI-ID 16217945]. Problema smo se lotili tako, da smo posplošene Petersenove grafe gledali v širšem kontekstu I-grafov in pokazali, da je vsak posplošeni Petersenov graf (razen nekaterih sporadičnih primerov, ki smo jih obravnavali posebej) izomorfen I-grafu, ki ima predstavitev z enotsko razdaljo v ravnini z rotacijsko simetrijo. Pri tem smo potrebovali tudi karakterizacijo za izomorfnost I-grafov z različnimi parametri [COBISS.SI-ID 16069977]. Na grafih z enotsko razdaljo smo preučevali tudi invariante, kot so dilacijski koeficient, ravninska širina ter resolucijski koeficient in odnose med njimi [COBISS.SI-ID 1024499540]. Vpeljali smo naravno posplošitev Petersenovih grafov, t.i. GI-grafe in popolnoma karakterizirali grupe avtomorfizmov za te grafe. To nam je omogočilo študij ostalih simetrijskih lastnosti, kot je točkovna tranzitivnost in kateri GI-grafi so Cayleyevi [COBISS.SI-ID 1024411732].

Definirali smo tudi posebne vrste krov nad poljubnim enostavnim grafom  $G$  in ga imenovali  $\text{TheCov}(G)$ , ki je popolnoma določen z grafom. Študirali smo simetrijske in grafovske lastnosti takih krovov [COBISS.SI-ID 16868185].

Vzpostavili smo tudi Enciklopedijo grafov (<http://atlas.gregas.eu>), ki jo prav tako dalje podpiramo v okviru infrastrukturnega programa na podjetju Abelium. Katalog 4-valentnih simetričnih grafov smo uspeli zapisati v zelo skrčeni obliki s pomočjo krovov.

## 2. Skoraj simetrične strukture in produkti grafov

Na področju splošne teorije izometričnih vložitev smo eksplicitno določili kanonično izometrično vložitev za grafe Sierpinskega [COBISS.SI-ID 16582233]. Poleg tega smo za to dvoparametrično družino grafov določili oz. podali meje za Hammingovo dimenzijo [COBISS.SI-ID 16416857]. Nadalje smo karakterizirali grafe Sierpinskega, ki so vpeti podgrafi grafov Hanojskega stolpa [COBISS.SI-ID 16590425].

Preučevane so bile metrične invariante grafov, kar vključuje tudi polinomske funkcije, Wienerjev indeks na uteženih grafih in metrično dimenzijo grafa. Pokazali smo, da se lahko Wienerjev indeks uteženih grafov izrazi kot vsota Wienerjevih indeksov uteženih kvocientnih grafov glede na poljubno kombinacijo Djokovic-Winkler razredov. Dodatno smo pokazali da se lahko uporabi metoda rezov za izračun poljubnih momentov razdalj za vse grafe, ki so izometrično vložljivi v kartezični produkt trikotnikov [COBISS.SI-ID 16590169, 16861017, 16768089, 16861017, 16893273].

Študirali smo tudi konveksnost, še posebej pa lastnosti konveksnih ciklov. Podali smo zgornjo mejo za število konveksnih ciklov v danem grafu in pogazali da velja enakost če in samo če je graf lih cikel ali Moorov graf (en članek poslan v objavo).

Preučevali so izometrične podgrafe hiperkock (ki so najenostavnejši večkratni kartezični produkti), predvsem Fibonaccijeve kocke in Lucasove kocke. Osredotočili smo se na različne metrike in povezane probleme na produktih grafih, med katerimi so (i)  $k$ -potno vektorsko pokritje, ki je grafovska invarianta povezana z varnostnimi vidiki v brezžičnih omrežjih, (ii)  $b$ -barvanja v krepkih produktih, leksikografskih produktih in direktnih produktih, (iii) varnostno število na mrežnih grafih (mreže, cilinder, torus), (iv) particijska dimenzija krepkih produktov in Kartezičnih produktov, (v)  $L(2,1)$ -označevanja produktov in  $L(3,2,1)$ -označevanja trikotniških in toroidalnih mrež, (vi) kromatično število in moč največje neodvisne množice kvadrata kartezičnih produktov ciklov. Na to temo je bilo objavljenih več del: [COBISS.SI-ID 16624473, 16590425, 16590169, 19464968, 17220697, 17087065, 16970585].

Razen tega smo napisali pregledni članek (ki med vsebuje tudi nove krajše dokaze znanih izrekov) o Fibonaccijevih kockah in sorodnih razredih grafov in s tem dodatno osvetlili Fibonaccijevo dimenzijo grafa [COBISS.SI-ID 16603737]

## 3. Rerezentacije simetričnih grafov

Na področju simetrij smo se ukvarjali z raziskavami snarkov in hamiltonskosti preko metode vlaganja grafov na ploskve. Raziskovalci na tem področju so dosegli izjemen uspeh s prestižno objavo [COBISS.SI-ID 1024390740].

Ukvarjali smo se s študijem krovnih grafov ter tudi z povezanostjo razdaljno uravnoveženih grafov [COBISS.SI-ID 1024329300]. Izvedli smo klasifikacijo visoko simetričnih grafov, med njimi kubičnih simetričnih tricirkulantov in tetracirkulantov, bicikličnih grafov z ekstremnim PI-indeksom. Ukvarjali smo se tudi z študijem grup avtomorfizmov racionalnih cirkulantnih grafov.

Na področju študija simetrij v grafih smo dalje študirali točkovno tranzitivne grafe. Točkovno tranzitivni grafi v splošnem kot tudi povezave med njimi in geometrijskimi objekti predstavljajo pomembno temo aktivnih raziskav že dlje časa. Večina interesa izvira iz dejstva da so primerni za modeliranje znanstvenih fenomenov povezanih s simetrijo. Naš cilj je bil raziskovati odprte probleme povezane s stukturinimi lastnostmi točkovno tranzitivnih grafov, še posebej tistih, ki

zadoščajo dodatnim grupno-teoretičnim lastnostim, kot so npr. ločna-tranzitivnost, pol-ločna-tranzitivnost in semisimetrična delovanja grup, s poudarkom na navezavo na odprte probleme na konfiguracijah in simetričnih zemljevidih. Dodatno smo uporabljali geometrijska orodja za reševanje problemov v teoriji točkovno tranzitivnih grafov, kot je zneni odprti problem Hamiltonovih poti/ciklov v točkovno tranzitivnih grafih. Na temo simetričnih grafov je bilo objavljenih več del COBISS.SI-ID: 1024446036, 1024510804, 1024533588, 1536117444, 1536086724, 1024490836, 1024470868, 1024486996, 1024490324, 1536085700, 1024511060, 1024532564, 1024516948, 1536241092, 1536423620, 1536423620, 1536920004, 1536280516, 1537120964, 1536172996, 1536382660].

#### 4. Reprezentacije konfiguracije, zemljevidov in politopov

Ukvarjali smo se s preučevanjem simetrijskih tipov zemljevidov na ploskvah ter vplivom operacij (duala) na njih [COBISS.SI-ID 16773465]. Objavili smo članek s klasifikacijo toroidalnih politopov, ki jih dobimo z razrezom prostorskega tlakovanja s kockami  $\{4,3,4\}$  [COBISS.SI-ID 16478297].

Vodja projekta prof. dr. Pisanski je v soavtorstvu z B. Servatius objavil tudi monografijo Configurations from a Graphical Viewpoint (Birkhäuser Advanced Texts Basler Lehrbücher) [COBISS.SI-ID 16418137].

Na področju učinkovitega generiranja grafov smo sodelovali z Univerzo v Gentu, Belgija [COBISS.SI-ID 16653401]. Objavljen je bil članek v povezavi s Haarovimi grafi in konfiguracijami [COBISS.SI-ID 1536194756]. Preučevali smo rotacijsko simetrične poligone in konfiguracije [COBISS.SI-ID 1024339284]

Na področju študija geometrijskih reprezentacij konfiguracij smo študirali  $g$ -laterale in geometrične in kombinatorične konfiguracije. Pokazali smo, da se v posebni družini konfiguracij lahko pojavi ali pa ne katera koli od osmih možnih kombinacij obstoja ali neobstoja  $g$ -lateral za  $3 \leq g \leq 5$ . Poleg tega smo prikazali geometrične realizacije za izbrane manjše primere 3-, 4- in 5-lateral prostih ( $v_3$ ) konfiguracij (posplošeni šestkotniki). Študirali smo tudi ( $v_4$ ) konfiguracije in identificirali najmanjšo znano geometrično 3-lateral prosto ( $v_4$ ) konfiguracijo. [COBISS.SI-ID 16089433]

#### 5. Reprezentacije velikih omrežij in aplikacije v kemiji, bioinformatiki ter socialnih omrežjih.

Razvili smo nove funkcionalnosti pri orodju net.Plexor, ki je alternativa orodju Pajek in se ga bo uporabljalo za analizo in vizualizacijo omrežij in ga ponudili v uporabo tudi v okviru infrastrukturnega programa na podjetju Abelium. V okviru izdelave programa se je izobraževalo več mladih raziskovalcev, ki so medtem že tudi doktorirali. Začel se je tudi razvoj na prototipnih programskih knjižnicah v Pythonu za časovna omrežja (TQ, Ianus).

Objavljen je bil članek, ki omogoča vizualizacijo s pomočjo  $(X,Y)$ -gručenja [COBISS.SI-ID 16097881]. Izvajali smo raziskave na področju implementacije gručenja po povezavah in ustrezne vizualizacije, pri čemer je sodeloval še en študent (Jernej Bodlaj).

V. Batagelj je skupaj z mlado raziskovalko v gospodarstvu Moniko Cerinšek objavil članek v reviji Scientometrics. Temeljila je na raziskavah na podatkovni bazi ZENTRALL BLATT for mathematics in sodelovalnih omrežjih avtorjev. Uvedene so bile ustrezne uteži v izračun omrežij sodelovanj, ki so omogočile realnejšo sliko prispevka (produktivnosti) posameznega avtorja in ustrežnejše določitve skupin sodelujočih avtorjev. Poleg tega smo lahko vpeljali ustrezno mero za sodelovalnost posameznega avtorja [COBISS.SI-ID 17149273, 16739929].

Monografija W. de Nooy, A. Mrvar, V. Batagelj, Exploratory Social Network Analysis with Pajek: Revised and Expanded 2nd Edition., Cambridge University Press, Cambridge, GB, 2012 [COBISS.SI-ID 30443869], je doživela ponovno razširjeno izdajo, poleg tega pa je bila izdana tudi v kitajskem jeziku [COBISS.SI-ID 31870813].

Začeli in intenzivno delali smo na raziskavah na področju dinamičnih velikih omrežij. Rezultat dela je objavljena monografija [COBISS.SI-ID 31563993]. Prispevali smo več prispevkov v obsežno Encyclopedia of Social Networks Analysis and Mining [COBISS.SI-ID 17138265, 17138521, 17138777, 17145433].

Sodelovali smo pri analizi podatkov o telefonskem prometu v Slonokoščeni obali d4d (data for development). Rezultate smo predstavili na srečanju skupin na MIT, ZDA. Ukvarjali smo se z razvojem novih metod za analizo velikih acikličnih omrežij (npr. omrežja sklicevanj - citation networks). Razvili smo nov, zelo hiter postopek za določanje pomembnosti vozlišč - verjetnostni (pre)tok (probabilistic flow). Za uteži povezav SPC smo pokazali, da je utež na posamezni povezavi manjša ali enaka od uteži na povezavah na poti, ki veže njeni krajišči. Torej lahko tranzitivnostne povezave odstranimo in dobimo preglednejšo sliko omrežja - tranzitivnostno ogrodje (skeleton). Razvili smo učinkovit postopek za določanje slednjega v velikih omrežjih.

Na področju kemijske teorije grafov smo preučevali uporabo prapornih grafov na benzenoidih [COBISS.SI-ID 16058713], [COBISS.SI-ID 16971097]. Objavili smo tudi članek na temo zanimive povezave Jahn-Tellerjevega izreka s teorijo grafov [COBISS.SI-ID 16090457], v prestižni reviji Proc. - Royal Soc., Math. phys. eng. sci. V povezavi z Jahn-Tellerjevimi problemi pa je prišlo do objave še enega članka [COBISS.SI-ID 16411737].

Ukvarjali smo se z grafičnimi predstavitvami DNK v ravnini s pomočjo zemljevidov ter s kvantitativno in računsko analizo teh. Štiri-črkovna zaporedja smo predstavili s pomočjo spiralne reprezentacije nad trikotniško in štirikotniško mrežo v ravnini v obliki 4-obarvanega zemljevida. Preučevali smo razne matrične invariante. [COBISS.SI-ID 16842585]

Študirali smo oblike reprezentacij spletnih strani in portalov s pomočjo grafov in predlagali različne organizacijske pristope. [COBISS.SI-ID 51728482].

#### 4. Ocena stopnje realizacije programa dela na raziskovalnem projektu in zastavljenih raziskovalnih ciljev<sup>3</sup>

Projekt se je izvedel v skladu z zastavljenimi cilji.

Mednarodno sodelovanje je bilo uspešno. Angažirani smo tudi v mrežne aktivnosti v sodelovanju z ESF. V okviru tega poročila opisujemo samo del projekta, ki se je izvajal v Sloveniji in je bil financiran s strani ARRS. Projekt ima tudi mednarodno dimenzijo, ki pa je prikazana v poročilih za Evropsko znanstveno fundacijo. Oddani sta bili tudi vmesno in končno poročilo Evropski znanstveni fundaciji. Vmesno poročilo je bilo pozitivno ocenjeno končno pa je še v postopku ocenjevanja. Oddani poročili sta pripeti temu poročilu.

#### 5. Utemeljitev morebitnih sprememb programa raziskovalnega projekta oziroma sprememb, povečanja ali zmanjšanja sestave projektne skupine<sup>4</sup>

V projektu ni večjih sprememb, kljub temu, da je s strani ARRS v letu 2012 in 2013 prišlo do znižanja sredstev.

#### 6. Najpomembnejši znanstveni rezultati projektne skupine<sup>5</sup>

Znanstveni dosežek			
1.	COBISS ID	16739929	Vir: COBISS.SI
	Naslov	<i>SLO</i>	O bibliografskih omrežjih
		<i>ANG</i>	On bibliographic networks

Opis	SLO	V članku pokažemo, da lahko bibliografske podatke pretvorimo v nabor usklajenih omrežij. Z množenjem omrežij lahko iz njih pridobimo več zanimivih izpeljanih omrežij. Pri njihovi definiciji je potrebno upoštevati ustrezno normalizacijo. Predstavljeni pristop je uporaben tudi za podobne nabore usklajenih omrežij z drugih področij. Omrežja, pridobljena iz bibliografskih podatkov, so lahko (zelo) velika (na sto tisoče vozlišč). K sreči so redka in jih za to še vedno lahko obdelamo razmeroma hitro. V članku damo odgovor na vprašanje: kdaj je zmnožek dveh redkih omrežij tudi sam redko omrežje. Predlagani pristopi so prikazani z analizo nabora omrežij na temo "social networks", pridobljenih iz Web of Science. Dela z velikim številom avtorjev dodajo običajnemu omrežju sodelovanj velike polne podgrafe in tako zameglijo sliko o sodelovanjih. Pokažemo, da lahko z ustrezno normalizacijo njihov učinek pridušimo. Med drugim vpeljemo mero sodelovalnosti avtorjev glede na dano bibliografijo in pokažemo, kako lahko izračunamo omrežje sklicevanj med avtorji in razkrijemo skupine glede na sklicevanje.	
	ANG	In the paper we show that the bibliographic data can be transformed into a collection of compatible networks. Using network multiplication different interesting derived networks can be obtained. In defining them an appropriate normalization should be considered. The proposed approach can be applied also to other collections of compatible networks. The networks obtained from the bibliographic data bases can be large (hundreds of thousands of vertices). Fortunately they are sparse and can be still processed relatively fast. We answer the question when the multiplication of sparse networks preserves sparseness. The proposed approaches are illustrated with analyses of collection of networks on the topic "social network" obtained from the Web of Science. The works with large number of co-authors add large complete subgraphs to standard collaboration network thus blurring the collaboration structure. We show that using an appropriate normalization their effect can be neutralized. Among other, we propose a measure of collaborativeness of authors with respect to a given bibliography and show how to compute the network of citations between authors and identify citation communities.	
	Objavljeno v	Springer; Akadémiai Kiadó; Scientometrics; 2013; Vol. 96, iss. 3; str. 845-864; Impact Factor: 2.274; Srednja vrednost revije / Medium Category Impact Factor: 1.031; A'': 1; A': 1; WoS: EV, NU; Avtorji / Authors: Batagelj Vladimir, Cerinšek Monika	
	Tipologija	1.01 Izvirni znanstveni članek	
2.	COBISS ID	16090457	Vir: COBISS.SI
Opis	Naslov	SLO	Teorija grafov in Jahn-Tellerjev izrek
		ANG	Graph theory and the Jahn-Teller theorem
		SLO	Jahn-Tellerjev izrek napoveduje spontano razbijanje simetrije in dvig degeneriranih elektronskih stanj nelinearnih molekularnih sistemov. V takih primerih se to zgodi zaradi geometrijskega popačenja. Molekularni problemi so pogosto modelirani s spektralno teorijo za obtežene grafe. Pričujoči prispevek obrne proces v nasprotno smer in na novo formulira Jahn-Tellerjev izrek za splošne utežene grafe. Če razumemo lastne vektorje kot orbitale, lastne vrednosti pa kot energijske nivoje, ki naj bi jih zasedli elektroni, tedaj je mogoče degeneracijo stanj razrešiti z ne popolnoma simetrično porazdelitvijo uteži na povezavah in, če je potrebno tudi na vozliščih grafa. V tej zvezi je postavljena tudi zanimiva domneva. Posebej sta obravnavana dva primera (graf oktaedra in graf fenalenila) saj se pri njiju degeniranost pojavlja zaradi različnih razlogov.
			The Jahn-Teller (JT) theorem predicts spontaneous symmetry breaking and lifting of degeneracy in degenerate electronic states of (nonlinear) molecular and solid-state systems. In these cases, degeneracy is lifted by

		ANG	geometric distortion. Molecular problems are often modelled using spectral theory for weighted graphs, and the present paper turns this process around and reformulates the JT theorem for general vertex- and edge-weighted graphs themselves. If the eigenvectors and eigenvalues of a general graph are considered as orbitals and energy levels (respectively) to be occupied by electrons, then degeneracy of states can be resolved by a non-totally symmetric re-weighting of edges and, where necessary, vertices. This leads to the conjecture that whenever the spectrum of a graph contains a set of bonding or anti-bonding degenerate eigenvalues, the roots of the Hamiltonian matrix over this set will show a linear dependence on edge distortions, which has the effect of lifting the degeneracy. When the degenerate level is non-bonding, distortions of vertex weights have to be included to obtain a full resolution of the eigenspace of the degeneracy. Explicit treatments are given for examples of the octahedral graph, where the degeneracy to be lifted is forced by symmetry, and the phenalenyl graph, where the degeneracy is accidental in terms of the automorphism group.
	Objavljeno v		Royal Society; Proceedings. Series A, Mathematical, Physical and Engineering Sciences; 2012; Vol. 468, no. 2140; str. 971-989; Impact Factor: 2.378; Srednja vrednost revije / Medium Category Impact Factor: 2.514; A': 1; WoS: RO; Avtorji / Authors: Ceulemans Arnout, Lijnen E., Fowler Patrick W., Mallion Roger B., Pisanski Tomaž
	Tipologija		1.01 Izvirni znanstveni članek
3.	COBISS ID	1024390740	Vir: COBISS.SI
	Naslov	SLO	1024390740
		ANG	Hamilton cycles in (2, odd, 3)-Cayley graphs
	Opis	SLO	Leta 1969 je Lovász postavil vprašanje, ali ima vsak končen, povezan točkovno-tranzitiven graf Hamiltonovo pot. Kljub enostavni formulaciji, do sedaj ni bil dosežen kak večji preboj in sedaj je splošno sprejeto, da gre za težek problem. Enako velja za poseben podrazred Cayleyevih grafov, kjer je postavljena domneva o obstoju Hamiltonovih ciklov. Leta 2007 sta Glover in Marušič dokazala, da ima Cayleyev kubični graf za končno $(2, i, 3)$ -generirano grupo $G = \langle x \mid x^2 = x^y = (ax)^3 = 1, \dots \rangle$ Hamiltonsko pot, če je $ G $ kongruentna 0 po modulu 4, in ima Hamiltonski cikel, če je $ G $ kongruentna 2 po modulu 4. Konstruiran je bil Hamiltonov cikel na osnovi kombinacije teorije Cayleyevih zemljevidov s klasičnimi rezultati o ciklični stabilnosti v kubičnih grafih, in sicer kot v točko stisljiv rob drevesa lic pripadajočega Cayleyevega zemljevida. Z posplošitvijo teh metod so Glover, Kutnar in Marušič v letu 2009 razrešili še primer, ko je poleg $ G $ še $\$ \$$ kongruenten 0 po modulu 4. V tem članku je z dodatno razširitvijo pristopa z "drevesom lic" dokazano, da ostaja Hamiltonov cikel tudi ko je $ G $ kongruentna 0 po modulu 4 in je $\$ \$$ lih. S tem ostane kot edini odprt primer še, ko je $ G $ kongruentna 0 po modulu 4 in je $\$ \$$ kongruentno 2 po modulu 4. V tem zadnjem primeru pristop preko "drevesa lic" ni mogoče uporabiti in tako bo za dokončanje dokaza o obstoju Hamiltonovih ciklov v kubičnih Cayleyevih grafih, ki izhajajo iz končnih $(2, i, 3)$ -generiranih grup, potrebno uporabiti popolnoma nove in drugačne metode.
			In 1969, Lovász asked if every finite, connected vertex-transitive graph has a Hamilton path. In spite of its easy formulation, no major breakthrough has been achieved thus far, and the problem is now commonly accepted to be very hard. The same holds for the special subclass of Cayley graphs where the existence of Hamilton cycles has been conjectured. In 2007, Glover and Marušič proved that a cubic Cayley graph on a finite $(2, s, 3)$ -generated group $G = \langle a, x \mid a^2 = x^s = (ax)^3 = 1, \dots \rangle$



			<p><math>\langle G \rangle</math> has a Hamilton path when <math> G </math> is congruent to 0 modulo 4, and has a Hamilton cycle when <math> G </math> is congruent to 2 modulo 4. The Hamilton cycle was constructed, combining the theory of Cayley maps with classical results on cyclic stability in cubic graphs, as the contractible boundary of a tree of faces in the corresponding Cayley map. With a generalization of these methods, Glover, Kutnar and Marušič in 2009 resolved the case when, apart from <math> G </math>, also <math>s</math> is congruent to 0 modulo 4. In this article, with a further extension of the above "tree of faces" approach, a Hamilton cycle is shown to exist whenever <math> G </math> is congruent to 0 modulo 4 and <math>s</math> is odd. This leaves <math> G </math> congruent to 0 modulo 4 with <math>s</math> congruent to 2 modulo 4 as the only remaining open case. In this last case, however, the "tree of faces" approach cannot be applied, and so entirely different techniques will have to be introduced if one is to complete the proof of the existence of Hamilton cycles in cubic Cayley graphs arising from finite <math>(2, s, 3)</math>-generated groups.</p>
	Objavljeno v	Clarendon Press; Proceedings of the London Mathematical Society; 2012; Vol. 104, no. 6; str. 1171-1197; Impact Factor: 1.151; Srednja vrednost revije / Medium Category Impact Factor: 0.673; A': 1; WoS: PQ; Avtorji / Authors: Glover Henry, Kutnar Klavdija, Malnič Aleksander, Marušič Dragan	
	Tipologija	1.01 Izvirni znanstveni članek	
4.	COBISS ID	16582233	Vir: COBISS.SI
	Naslov	SLO	O razdaljah v grafih Sierpinskega: skoraj-ekstremna vozlišča in metrična dimenzija.
		ANG	On distances in Sierpiński graphs: almost-extreme vertices and metric dimension
	Opis	SLO	Grafi Sierpiškega $S_p^n$ tvorijo intenzivno raziskovano družino grafov fraktalne narave. Uporabni so v topologiji, matematiki Hanojskega stolpa, računalništvu, ter drugod. V članku vpeljemo skoraj-ekstremna vozlišča grafa $S_p^n$ kot vozlišča, ki so bodisi sosedna z nekim ekstremnim vozliščem, ali pa so incidenčna povezavi med dvema podgrafoma izomorfornima $S_{p-1}^n$ . Podane so eksplicitne formule za razdalje v $S_p^n$ med poljubnim vozliščem in skoraj-ekstremnim vozliščem. Formule so uporabljene za izračun celotne razdalje skoraj-ekstremnih vozlišč in za določitev metrične dimenzije grafov Sierpiškega.
		ANG	Sierpiński graphs $S_p^n$ form an extensively studied family of graphs of fractal nature applicable in topology, mathematics of the Tower of Hanoi, computer science, and elsewhere. An almost-extreme vertex of $S_p^n$ is introduced as a vertex that is either adjacent to an extreme vertex of $S_p^n$ or is incident to an edge between two subgraphs of $S_p^n$ isomorphic to $S_{p-1}^n$ . Explicit formulas are given for the distance in $S_p^n$ between an arbitrary vertex and an almost-extreme vertex. The formulas are applied to compute the total distance of almost-extreme vertices and to obtain the metric dimension of Sierpiński graphs.
	Objavljeno v	Faculty of Electrical Engineering, Department of Applied Mathematics; Applicable analysis and discrete mathematics; 2013; Vol. 7, no. 1; str. 72-82; Impact Factor: 0.708; Srednja vrednost revije / Medium Category Impact Factor: 0.674; WoS: PN, PQ; Avtorji / Authors: Klavžar Sandi, Zemljič Sara Sabrina	
	Tipologija	1.01 Izvirni znanstveni članek	
5.	COBISS ID	1536241092	Vir: COBISS.SI
	Naslov	SLO	Pol-ločno-tranzitivni grafi z majhnim številom alter-mrež
		ANG	Half-arc-transitive graphs with small number of alternets
			Grafu $X$ rečemo da je $G$ -pol-ločno tranzitiven, če $G \leq \text{Aut}(X)$ deluje

Opis	SLO	tranzitivno na množici vozlišč grafa X in na množici povezav grafa X, ampak ne deluje tranzitivno na množici lokov X. Take grafe lahko preučujemo preko t.i. alter-mrež (ang. alternets), to so ekvivalenčni razredi po relaciji dosegljivosti, ki je bila prvič predstavljena s strani avtorjev Cameron, Praeger in Wormald (1993). Če množici vozlišč dveh sosednjih alternetov bodisi sovpadata ali se sekata v polovici vozlišč pravimo, da je graf tesno spet. V članku preučujemo grafe z pol-ločno-tranzitivnim delovanjem grupe z največ pet alter-mrež. Če je število alter-mrež največ tri, pokažemo da je graf nujno testno spet. A obstajajo grafi z štirimi in petimi alter-mrežami, ki niso tesno speti. Vse te posebne grafe lahko razčlenimo ki jih lahko razčlenimo na particijo, ki nam da grafa $R_6(5,4)R_6(5,4)$ ("Rose window" graf) ter poseben graf na 20 vozliščih v primeru petih alter-mrež.
	ANG	A graph X is said to be G-half-arc-transitive if $G \leq \text{Aut}(X)$ acts transitively on the set of vertices of X and on the set of edges of X but does not act transitively on the set of arcs of X. Such graphs can be studied via corresponding alternets, that is, equivalence classes of the so-called reachability relation, first introduced by Cameron, Praeger and Wormald (1993). If the vertex sets of two adjacent alternets either coincide or have half of their vertices in common the graph is said to be tightly attached. In this paper graphs admitting a half-arc-transitive group action with at most five alternets are considered. In particular, it is shown that if the number of alternets is at most three, then the graph is necessarily tightly attached, but there exist graphs with four and graphs with five alternets which are not tightly attached. The exceptional graphs all admit a partition giving the rose window graph $R_6(5,4)R_6(5,4)$ on 12 vertices as a quotient graph in case of four alternets, and a particular graph on 20 vertices in the case of five alternets.
Objavljeno v	Academic Press; Journal of combinatorial theory. Series A; 2014; Vol. 124, iss. 2; str. 114-129; Impact Factor: 0.868; Srednja vrednost revije / Medium Category Impact Factor: 0.674; A': 1; WoS: PQ; Avtorji / Authors: Hujdurović Ademir, Kutnar Klavdija, Marušič Dragan	
Tipologija	1.01 Izvirni znanstveni članek	

## 7. Najpomembnejši družbeno-ekonomski rezultati projektne skupine<sup>6</sup>

Družbeno-ekonomski dosežek		
1.	COBISS ID	Vir: vpis v poročilo
Naslov	SLO	Tomaž Pisanski, Dragan Marušič ustanovna in glavna urednika znanstvene publikacije
	ANG	Tomaž Pisanski, Dragan Marušič, founding and editors in chief of a scientific journal
Opis	SLO	Ars mathematica contemporanea. Pisanski, Tomaž (glavni in odgovorni urednik 2008). [Tiskana izd.]. Ljubljana: Društvo matematikov, fizikov in astronomov, 2008. ISSN 18553966. <a href="http://amc-journal.eu">http://amc-journal.eu</a> [COBISS.SI ID 239049984]. Revija je na SCI lestvici in je imela v letu 2011 impact factor 0,4 (mathematics)
	ANG	Ars mathematica contemporanea. Pisanski, Tomaž (founding and editor in chief 2008). [Printed ed.]. Ljubljana: Slovenian society of mathematicians, physicists and astronomers, 2008. ISSN 18553966. <a href="http://amc-journal.eu">http://amc-journal.eu</a> . [COBISS.SIID 239049984]. The journal was accepted to SCI.
Šifra	C.04 Uredništvo mednarodne revije	
Objavljeno v	Ars mathematica contemporanea, <a href="http://amc-journal.eu">http://amc-journal.eu</a>	
Tipologija	4.00 Sekundarno avtorstvo	

2.	COBISS ID		267243264	Vir: COBISS.SI	
	Naslov	SLO	Organizacija in objava zbornika povzetkov mednarodne konference "CSASC 2013"		
		ANG	Organization and publication of proceedings of international conference "CSASC 2013"		
	Opis	SLO	Tomaž Pisanski, Klavdija Kutnar, Alen Orbanič - člani organizacijskega odbora, <a href="http://csasc2013.upr.si/">http://csasc2013.upr.si/</a> , Skupna matematična konferenca matematičnih društev Katalonije, Slovenije, Avstrije, Slovaške in Češke.		
		ANG	Tomaž Pisanski, Klavdija Kutnar, Alen Orbanič - members of the organizing committee, <a href="http://csasc2013.upr.si/">http://csasc2013.upr.si/</a> , Joint Mathematical Conference of the Catalan, Slovenian, Austrian, Slovak and Czech Mathematical Societies		
	Šifra	B.01 Organizator znanstvenega srečanja			
	Objavljeno v	University of Primorska Press; 2013; 101 str.; Avtorji / Authors: Hujdurovič Ademir, Frelih Boštjan, Kutnar Klavdija, Prezelj-Perman Jasna, Pisanski Tomaž, Orbanič Alen			
Tipologija	2.30 Zbornik strokovnih ali nerecenziranih znanstvenih prispevkov na konferenci				
3.	COBISS ID			Vir: vpis v poročilo	
	Naslov	SLO	Izvolitev v Academia Europaea		
		ANG	Election to Academia Europaea		
	Opis	SLO	Prof. dr. Tomaž Pisanski je bil izvoljen v prestižno Academio Europeae v sekcijo informatika.		
		ANG	Prof. dr. Tomaž Pisanski was elected to prestigious membership of Academio Europeae, section informatics.		
	Šifra	D.03 Članstvo v tujih/mednarodnih odborih/komitejih			
	Objavljeno v	<a href="http://www.ae-info.org/ae/User/Pisanski_Toma%C5%BE">http://www.ae-info.org/ae/User/Pisanski_Toma%C5%BE</a>			
Tipologija	4.00 Sekundarno avtorstvo				
4.	COBISS ID		16418137	Vir: COBISS.SI	
	Naslov	SLO	Konfiguracije iz vidika teorije grafov		
		ANG	Configurations from a graphical viewpoint		
	Opis	SLO	Konfiguracije, ki jih lahko preučujemo iz vidika teorije grafov preko Levijevih grafov, ležijo v preseku teorije grafov, grup, ploskev in geometrije, ki predstavljajo zelo aktivna področja matematičnih raziskav. V knjigi oblikovani kot zaključena celota je algebraična teorija grafov uporabljena za predstavitev grup, topološka teorija grafov je uporabljena za preučevanje ploskev, geometrična teorija grafov pa nam olajša razumevanje incidenčnih geometrij. Po pregledu konfiguracij v 1. poglavju predstavimo v 2. poglavju teorijo grafov, v 3. poglavju pa podamo geometrično orientiran uvod v teorijo grup. V 4. poglavju predstavimo kombinatorično obravnavo zemljevidov in ploskev. V 5. poglavju predstavimo koncept incidenčne strukture preko po točkah obarvanih grafov. Tu tudi podamo kombinatorične vidike klasičnih konfiguracij. V zadnjem poglavju za klasične konfiguracije podamo nekaj zanimivih geometričnih lastnosti, zgodovinskih opomb, referenc in aplikacij. S preko 200 ilustracijami, nalogami in obsežno bibliografijo na koncih poglavij ter množico podanih odprtih problemov predstavlja knjiga dobro osnovo za podiplomski tečaj iz teorije grafov, napreden dodiplomski seminar kot tudi celovito referenco za matematike in raziskovalce.		
			On the back cover page: Configurations can be studied from a graph-theoretical viewpoint via the so-called Levi graphs and lie at the heart of		

		graphs, groups, surfaces, and geometries, all of which are very active areas of mathematical exploration. In this self-contained textbook, algebraic graph theory is used to introduce groups; topological graph theory is used to explore surfaces; and geometric graph theory is implemented to analyze incidence geometries. After a preview of configurations in Chapter 1, a concise introduction to graph theory is presented in Chapter 2, followed by a geometric introduction to groups in Chapter 3. Maps and surfaces are combinatorially treated in Chapter 4. Chapter 5 introduces the concept of incidence structure through vertex colored graphs, and the combinatorial aspects of classical configurations are studied. Geometric aspects, some historical remarks, references, and applications of classical configurations appear in the last chapter. With over two hundred illustrations, challenging exercises at the end of each chapter, a comprehensive bibliography, and a set of open problems, Configurations from a Graphical Viewpoint is well suited for a graduate graph theory course, an advanced undergraduate seminar, or a self-contained reference for mathematicians and researchers.
	Šifra	D.11 Drugo
	Objavljeno v	Birkhäuser; 2013; XIII, 279 str.; A": 1;A': 1; Avtorji / Authors: Pisanski Tomaž, Servatius Brigitte
	Tipologija	2.01 Znanstvena monografija
5.	COBISS ID	5048602 Vir: COBISS.SI
	Naslov	SLO Organizacija in objava zbornika povzetkov mednarodnega srečanja "Computers in Scientific Discovery 6"
		ANG Organization and publication of proceedings of international workshop "Computers in Scientific Discovery 6"
	Opis	SLO Organizacija in objava zbornika povzetkov mednarodnega srečanja "Computers in Scientific Discovery 6" s področja uporabe računalnikov v znanosti. Plenarni govorec je bil znani nobelovec Sir Harald Kroto. Konferenca se je udeležilo več uglednih tujih in domačih znanstvenikov. Konferenca je bila organizirana v Portorožu avgusta 2012. <a href="http://csd6.imfm.si">http://csd6.imfm.si</a>
		ANG Organization and publication of proceedings of international workshop "Computers in Scientific Discovery 6" on the topics of computer use in sciences. The plenary speaker of the conference was Sir Harald Kroto, a reputable Nobel laureate. Several prominent scientists from various fields attended the conference. Conference was organized in Portorož in August 2012. <a href="http://csd6.imfm.si">http://csd6.imfm.si</a>
	Šifra	B.01 Organizator znanstvenega srečanja
	Objavljeno v	[s. n.]; 2012; 52 str.; Avtorji / Authors: Fowler Patrick W., Frelih Boštjan, Horvat Boris, Hujdurovič Ademir, Kutnar Klavdija, Orbanić Alen, Pisanski Tomaž
	Tipologija	2.25 Druge monografije in druga zaključena dela

## 8. Drugi pomembni rezultati projektne skupine<sup>Z</sup>

Revija *Ars Mathematica Contemporanea*, ki sta jo ustanovila prof. dr. Tomaž Pisanski in prof. dr. Dragan Marušič se je uvrstila na seznam SCI kot prva mednarodna matematična revija s področja matematike v Sloveniji.

D. Marušič je v letu 2011 postal rektor Univerze na Primorskem.

Š. Miklavič je prejel Zoisovo nagrado.

K. Kutnar, A. Malnič in D. Marušič, so dosegli izjemen uspeh. V soavtorstvu z žal že pokojnim prof. dr. Henryem Gloverjem iz Ohio State University so objavili razpravo »Hamilton cycles in (2, odd, 3) - Cayley graphs« v eni najprestižnejših matematičnih revij »Proceedings of the London Mathematical Society«, ki izhaja že od leta 1865.

V. Batagelj je prejel nagrado INSNA's 2013 William D. Richards Software award za program Pajek.

Organizacija konferenc:

- Fourth Workshop on Formal Topology, Univerza v Ljubljani od 15. do 19. junija 2012.
- Workshop on Higher-dimensional Algebra, Categories and Types, 20. junija 2012 na Univerzi v Ljubljani.
- SODO 2012, Symmetries of Discrete Objects, Conference and MAGMA Workshop, Queenstown, New Zealand, 13-17 February 2012
- ATCAGC 2013: Algebraic, Topological and Complexity Aspects of Graph Covers, Bovec, Slovenia / 28 January - 1 February 2013
- Joint Workshop of Math Departments UP IAM and UP FAMNIT, Rogla, Slovenia / 17 - 19 May 2013
- CSASC 2013: Joint Mathematical Conference, Koper, Slovenia / 9 - 13 June 2013
- PhD Summer School in Discrete Mathematics, Rogla, Slovenia / 16 - 21 June 2013
- Conference on Geometry: Theory and Applications, Ljubljana, Slovenia / 24 - 28 June 2013
- Ljubljana-Leoben Graph Theory Seminar, 3-5 September, 2014, Koper, Slovenia
- 2014 PhD Summer School in Discrete Mathematics, Rogla, Slovenia / 29 June - 5 July 2014
- SYGN IV: Symmetries of Graphs and Networks IV, Rogla, Slovenia / 29 June - 5 July 2014

## 9. Pomen raziskovalnih rezultatov projektne skupine<sup>8</sup>

### 9.1. Pomen za razvoj znanosti<sup>2</sup>

SLO

To je bil prestižni projekt, podeljen s strani Evropske znanstvene fundacije preko programa EUROCORES/EuroGIGA. Pomemben je bil tudi zato, ker gre za enega redkih projektov, katerega vodja je bil Slovenec. To predstavlja pomembno priznanje slovenske teorije grafov, katere ustanovitelj je bil pred nekaj desetletji prav prof. Pisanski.

V okviru projekta je bilo doseženih in objavljenih veliko pomembnih znanstvenih rezultatov, tako s strani uveljavljenih kot tudi mlajših znanstvenikov. Ti rezultati še dodatno potrjujejo kakovost in moč slovenske teorije grafov. Na področju teorije grafov delujejo v Sloveniji štirje raziskovalni programi. Trije najbolj uveljavljeni so bili vključeni v projekt. Vključene so bile tudi vse tri glavne univerze.

Med izvajanjem projekta smo organizirali več mednarodnih aktivnosti mreženja (konference, delavnice), ki so dodatno prispevale k povečanju mednarodne vpetosti. Uspešno sodelovanje s partnerji iz industrije na projektu bo v prihodnosti še dodatno prispevalo relevantne izzive iz gospodarstva, ki bodo vzpodbujali bolj ekonomsko relevantne raziskave z večjim učinkom, predvsem na področju analize velikih omrežij, socialnih omrežij in transportnih omrežij.

Več mladih raziskovalcev je bilo vzgojeno tekom izvajanja projekta. Nekateri rezultati so bili objavljeni vrhunskih revijah na tem področju raziskav.

ANG

This was a prestigious project awarded by European Science Foundation under EUROCORES/EuroGIGA programme. It is important because it is one of the rare projects in the EUROCORES programme with the project leader from Slovenia. This is an important recognition of Slovenian graph theory schools, that started many decades ago with T. Pisanski being a pioneer.

Several new scientific results have been achieved in this field, by senior scientists as well as young ones, thus indicating the strength and the importance of the Slovenian graph theory. Four of seven mathematical research programmes work in this field, while three most

established ones took part in the project. All three main Slovenian universities were involved.

Networking activities organized within the project contributed to further development of the scientific collaboration network and increasing our research impact. Successful cooperation with the partners from industry opened new opportunities for a more focused research with higher impact motivated by real-world problems in large network analysis, social networks and transportation networks.

Working on topic related to the project several new young researchers were raised. Some of the publications were published in top journals in the field.

## 9.2. Pomen za razvoj Slovenije<sup>10</sup>

*SLO*

Projekt dodeljen s strani Evropske znanstvene fundacije slovenskemu vodji predstavlja pomembno priznanje za Slovenijo - preko uveljavljenega matematičnega področja, teorije grafov. Projekt je tako še dodatno utrdil prepoznavnost Slovenije na tem področju.

V projektu je poleg akademskih institucij sodelovalo še uspešno visoko-tehnološko podjetje Abelium, ki je pred leti nastalo kot "spin-off" iz raziskovalne skupine in programa P1-0294, katerega vodja je prof. T. Pisanski. S tem smo dodatno približali probleme iz gospodarstva raziskovalni sferi, predvsem na področju analize omrežij, socialnih in transportnih. Vrhunska znanstvena dognanja, kompetence in veščine se tako sistematično uporabljajo in nadgrajujejo tudi pri razvoju novih visokotehnoloških rešitev, za katere je podjetje v sodelovanju z različnimi globalnimi partnerji v zadnjih letih prejelo več inovacijskih nagrad (GoOpti, iOliva).

Potrditve kakovosti slovenske teorije grafov je v zadnjih letih prišla tudi s sprejetjem prve slovenske matematične znanstvene revije *Ars Mathematica Contemporanea* na lestvico SCI. Dodatno je bil prof. Pisanski sprejet v *Academia Europae*. Pajek, orodje za analizo velikih omrežij, je bil priznan za enega najpomembnejših akademskih orodij in je prejel nagrado s strani INSNA (International Network for Social Network Analysis): 2013 William D. Richards Software award. Med izvajanjem projekta in tudi kot del njega se tako strategija o doseganju vrhunske znanstvene odličnosti slovenske teorije grafov izpolnjuje ter odpira nove možnosti za doseganje močne vpetosti v gospodarstvo in ekonomsko relevantne učinke.

*ANG*

The project awarded by European Science Foundation to a Slovenian leader represents a high level of recognition to Slovenia - through the established mathematical field of graph theory. The project thus contributed additional increase of the visibility of Slovenia in this field.

Beside the academic institutions, a successful hi-tech company Abelium was involved as a partner, a spin-off from the research group and the programme P1-0294, lead by T. Pisanski. This has contributed to bridging the gap between business and research, especially in the fields of network analysis in social and transportation networks. Top scientific knowledge, competences and skills are systematically used and upgraded during development of hi-tech solutions - the ones the company have received several innovation awards in the past years (GoOpti, iOliva).

In the past few years Slovenian graph theory received additional recognition through *Ars Mathematica Contemporanea*, the first Slovenian mathematical scientific journal being indexed by SCI (since 2011). In addition, T. Pisanski was accepted to *Academia Europae*. Pajek, a large network analysis tool, was recognized as one of the top academic tools in the field and received the INSNA's 2013 William D. Richards Software award, by International Network for Social Network Analysis. The strategy of achieving scientific excellence of Slovenian graph theory was successfully carried out during the course of the project, additionally opening new opportunities for achieving better integration with business thus having higher economic relevance.

**10.Samo za aplikativne projekte in podoktorske projekte iz gospodarstva!**

Označite, katerega od navedenih ciljev ste si zastavili pri projektu, katere konkretne rezultate ste dosegli in v kakšni meri so doseženi rezultati uporabljeni

Cilj		
<b>F.01</b>	<b>Pridobitev novih praktičnih znanj, informacij in veščin</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.02</b>	<b>Pridobitev novih znanstvenih spoznanj</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.03</b>	<b>Večja usposobljenost raziskovalno-razvojnega osebja</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.04</b>	<b>Dvig tehnološke ravni</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.05</b>	<b>Sposobnost za začetek novega tehnološkega razvoja</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.06</b>	<b>Razvoj novega izdelka</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.07</b>	<b>Izboljšanje obstoječega izdelka</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.08</b>	<b>Razvoj in izdelava prototipa</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.09</b>	<b>Razvoj novega tehnološkega procesa oz. tehnologije</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>

	Uporaba rezultatov	<input type="text"/>
<b>F.10</b>	<b>Izboljšanje obstoječega tehnološkega procesa oz. tehnologije</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.11</b>	<b>Razvoj nove storitve</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.12</b>	<b>Izboljšanje obstoječe storitve</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.13</b>	<b>Razvoj novih proizvodnih metod in instrumentov oz. proizvodnih procesov</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.14</b>	<b>Izboljšanje obstoječih proizvodnih metod in instrumentov oz. proizvodnih procesov</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.15</b>	<b>Razvoj novega informacijskega sistema/podatkovnih baz</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.16</b>	<b>Izboljšanje obstoječega informacijskega sistema/podatkovnih baz</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.17</b>	<b>Prenos obstoječih tehnologij, znanj, metod in postopkov v prakso</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.18</b>	<b>Posredovanje novih znanj neposrednim uporabnikom (seminarji, forumi, konference)</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>



<b>F.19</b>	<b>Znanje, ki vodi k ustanovitvi novega podjetja ("spin off")</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.20</b>	<b>Ustanovitev novega podjetja ("spin off")</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.21</b>	<b>Razvoj novih zdravstvenih/diagnostičnih metod/postopkov</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.22</b>	<b>Izboljšanje obstoječih zdravstvenih/diagnostičnih metod/postopkov</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.23</b>	<b>Razvoj novih sistemskih, normativnih, programskih in metodoloških rešitev</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.24</b>	<b>Izboljšanje obstoječih sistemskih, normativnih, programskih in metodoloških rešitev</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.25</b>	<b>Razvoj novih organizacijskih in upravljaljskih rešitev</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.26</b>	<b>Izboljšanje obstoječih organizacijskih in upravljaljskih rešitev</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.27</b>	<b>Prispevek k ohranjanju/varovanje naravne in kulturne dediščine</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.28</b>	<b>Priprava/organizacija razstave</b>	

	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.29</b>	<b>Prispevek k razvoju nacionalne kulturne identitete</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.30</b>	<b>Strokovna ocena stanja</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.31</b>	<b>Razvoj standardov</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.32</b>	<b>Mednarodni patent</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.33</b>	<b>Patent v Sloveniji</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.34</b>	<b>Svetovalna dejavnost</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>
<b>F.35</b>	<b>Drugo</b>	
	Zastavljen cilj	<input type="radio"/> DA <input type="radio"/> NE
	Rezultat	<input type="text"/>
	Uporaba rezultatov	<input type="text"/>

**Komentar**

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**11.Samo za aplikativne projekte in podoktorske projekte iz gospodarstva!**  
**Označite potencialne vplive oziroma učinke vaših rezultatov na navedena področja**

	<b>Vpliv</b>	<b>Ni vpliva</b>	<b>Majhen vpliv</b>	<b>Srednji vpliv</b>	<b>Velik vpliv</b>	

<b>G.01</b>	<b>Razvoj visokošolskega izobraževanja</b>					
G.01.01.	Razvoj dodiplomskega izobraževanja	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.01.02.	Razvoj podiplomskega izobraževanja	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.01.03.	Drugo:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<b>G.02</b>	<b>Gospodarski razvoj</b>					
G.02.01	Razširitev ponudbe novih izdelkov/storitev na trgu	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.02.	Širitev obstoječih trgov	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.03.	Znižanje stroškov proizvodnje	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.04.	Zmanjšanje porabe materialov in energije	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.05.	Razširitev področja dejavnosti	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.06.	Večja konkurenčna sposobnost	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.07.	Večji delež izvoza	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.08.	Povečanje dobička	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.09.	Nova delovna mesta	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.10.	Dvig izobrazbene strukture zaposlenih	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.11.	Nov investicijski zagon	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.02.12.	Drugo:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<b>G.03</b>	<b>Tehnološki razvoj</b>					
G.03.01.	Tehnološka razširitev/posodobitev dejavnosti	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.03.02.	Tehnološko prestrukturiranje dejavnosti	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.03.03.	Uvajanje novih tehnologij	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.03.04.	Drugo:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<b>G.04</b>	<b>Družbeni razvoj</b>					
G.04.01	Dvig kvalitete življenja	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.04.02.	Izboljšanje vodenja in upravljanja	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.04.03.	Izboljšanje delovanja administracije in javne uprave	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.04.04.	Razvoj socialnih dejavnosti	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.04.05.	Razvoj civilne družbe	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.04.06.	Drugo:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<b>G.05.</b>	<b>Ohranjanje in razvoj nacionalne naravne in kulturne dediščine in identitete</b>					
<b>G.06.</b>	<b>Varovanje okolja in trajnostni razvoj</b>					
<b>G.07</b>	<b>Razvoj družbene infrastrukture</b>					
G.07.01.	Informacijsko-komunikacijska infrastruktura	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.07.02.	Prometna infrastruktura	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
G.07.03.	Energetska infrastruktura	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

G.07.04.	Drugo:		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<b>G.08.</b>	<b>Varovanje zdravja in razvoj zdravstvenega varstva</b>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	
<b>G.09.</b>	<b>Drugo:</b>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	

**Komentar**

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**12.Pomen raziskovanja za sofinancerje<sup>11</sup>**

	Sofinancer		
1.	Naziv	/	
	Naslov	/	
	Vrednost sofinanciranja za celotno obdobje trajanja projekta je znašala:	0	EUR
	Odstotek od utemeljenih stroškov projekta:	0	%
	Najpomembnejši rezultati raziskovanja za sofinancerja		Šifra
		1.	
		2.	
		3.	
		4.	
		5.	
	Komentar		
	Ocena	/	

**13.Izjemni dosežek v letu 2014<sup>12</sup>****13.1. Izjemni znanstveni dosežek**

Kategorija:

GÓMEZ-NÚÑEZ, Antonio J., BATAGELJ, Vladimir, VARGAS-QUESADA, Benjamín, MOYA-ANEGÓN, Félix de, CHINCHILLA-RODRÍGUEZ, Zaida. Optimizing SCImago Journal & Country Rank classification by community detection. Journal of informetrics, ISSN 1751-1577, 2014, vol. 8, iss. 2, str. 369-383. <http://dx.doi.org/10.1016/j.joi.2014.01.011>. [COBISS.SI-ID 17105241]

kategorija: 1A1 (Z, A", A', A1/2); uvrstitev: SSCI, Scopus (d), Scopus, MBP; tipologijo je verificiral OSICD

V članku sta predstavljeni dve novi bibliografski klasifikaciji po predmetu pridobljeni s pomočjo orodja Pajek in algoritmov za razvrščanje na omrežju 18.000 revij na platformi SCImago Journal & Country Rank (SJR). Izvedena je primerjava z obstoječimi klasifikacijami SJR in WoS.

**13.2. Izjemni družbeno-ekonomski dosežek**

/
---

**C. IZJAVE**

Podpisani izjavljam/o, da:

- so vsi podatki, ki jih navajamo v poročilu, resnični in točni
- se strinjamo z obdelavo podatkov v skladu z zakonodajo o varstvu osebnih podatkov za potrebe ocenjevanja ter obdelavo teh podatkov za evidence ARRS
- so vsi podatki v obrazcu v elektronski obliki identični podatkom v obrazcu v pisni obliki
- so z vsebino zaključnega poročila seznanjeni in se strinjajo vsi soizvajalci projekta

**Podpisi:**

*zastopnik oz. pooblaščen oseba  
raziskovalne organizacije:*

in

*vodja raziskovalnega projekta:*

Univerza na Primorskem, Inštitut  
Andrej Marušič

Tomaž Pisanski

---

**ŽIG**

Kraj in datum:

Koper

16.3.2015

**Oznaka poročila: ARRS-RPROJ-ZP-2015/227**

<sup>1</sup> Napišite povzetek raziskovalnega projekta (največ 3.000 znakov v slovenskem in angleškem jeziku) [Nazaj](#)

<sup>2</sup> Napišite kratko vsebinsko poročilo, kjer boste predstavili raziskovalno hipotezo in opis raziskovanja. Navedite ključne ugotovitve, znanstvena spoznanja, rezultate in učinke raziskovalnega projekta in njihovo uporabo ter sodelovanje s tujimi partnerji. Največ 12.000 znakov vključno s presledki (približno dve strani, velikost pisave 11). [Nazaj](#)

<sup>3</sup> Realizacija raziskovalne hipoteze. Največ 3.000 znakov vključno s presledki (približno pol strani, velikost pisave 11) [Nazaj](#)

<sup>4</sup> V primeru bistvenih odstopanj in sprememb od predvidenega programa raziskovalnega projekta, kot je bil zapisan v predlogu raziskovalnega projekta oziroma v primeru sprememb, povečanja ali zmanjšanja sestave projektne skupine v zadnjem letu izvajanja projekta, napišite obrazložitev. V primeru, da sprememb ni bilo, to navedite. Največ 6.000 znakov vključno s presledki (približno ena stran, velikost pisave 11). [Nazaj](#)

<sup>5</sup> Navedite znanstvene dosežke, ki so nastali v okviru tega projekta. Raziskovalni dosežek iz obdobja izvajanja projekta (do oddaje zaključnega poročila) vpišete tako, da izpolnite COBISS kodo dosežka – sistem nato sam izpolni naslov objave, naziv, IF in srednjo vrednost revije, naziv FOS področja ter podatek, ali je dosežek uvrščen v A" ali A'. [Nazaj](#)

<sup>6</sup> Navedite družbeno-ekonomske dosežke, ki so nastali v okviru tega projekta. Družbeno-ekonomski rezultat iz obdobja izvajanja projekta (do oddaje zaključnega poročila) vpišete tako, da izpolnite COBISS kodo dosežka – sistem nato sam izpolni naslov objave, naziv, IF in srednjo vrednost revije, naziv FOS področja ter podatek, ali je dosežek uvrščen v A" ali A'.

Družbeno-ekonomski dosežek je po svoji strukturi drugačen kot znanstveni dosežek. Povzetek znanstvenega dosežka je praviloma povzetek bibliografske enote (članka, knjige), v kateri je dosežek objavljen.

Povzetek družbeno-ekonomskega dosežka praviloma ni povzetek bibliografske enote, ki ta dosežek dokumentira, ker je dosežek sklop več rezultatov raziskovanja, ki je lahko dokumentiran v različnih bibliografskih enotah. COBISS ID zato ni enoznačen, izjemoma pa ga lahko tudi ni (npr. prehod mlajših sodelavcev v gospodarstvo na pomembnih raziskovalnih nalogah, ali ustanovitev podjetja kot rezultat projekta ... - v obeh primerih ni COBISS ID). [Nazaj](#)

<sup>7</sup> Navedite rezultate raziskovalnega projekta iz obdobja izvajanja projekta (do oddaje zaključnega poročila) v primeru, da katerega od rezultatov ni mogoče navesti v točkah 6 in 7 (npr. ni voden v sistemu COBISS). Največ 2.000 znakov, vključno s presledki. [Nazaj](#)

<sup>8</sup> Pomen raziskovalnih rezultatov za razvoj znanosti in za razvoj Slovenije bo objavljen na spletni strani: <http://sicris.izum.si/> za posamezen projekt, ki je predmet poročanja [Nazaj](#)

<sup>9</sup> Največ 4.000 znakov, vključno s presledki [Nazaj](#)

<sup>10</sup> Največ 4.000 znakov, vključno s presledki [Nazaj](#)

<sup>11</sup> Rubrike izpolnite / prepisite skladno z obrazcem "izjava sofinancerja" <http://www.arrs.gov.si/sl/progproj/rproj/gradivo/>, ki ga mora izpolniti sofinancer. Podpisan obrazec "Izjava sofinancerja" pridobi in hrani nosilna raziskovalna organizacija –

izvajalka projekta. [Nazaj](#)

<sup>12</sup> Navedite en izjemni znanstveni dosežek in/ali en izjemni družbeno-ekonomski dosežek raziskovalnega projekta v letu 2014 (največ 1000 znakov, vključno s presledki). Za dosežek pripravite diapozitiv, ki vsebuje sliko ali drugo slikovno gradivo v zvezi z izjemnim dosežkom (velikost pisave najmanj 16, približno pol strani) in opis izjemnega dosežka (velikost pisave 12, približno pol strani). Diapozitiv/-a priložite kot priponko/-i k temu poročilu. Vzorec diapozitiva je objavljen na spletni strani ARRS <http://www.rrs.gov.si/sl/gradivo/>, predstavitev dosežkov za pretekla leta pa so objavljena na spletni strani <http://www.rrs.gov.si/sl/analize/dosez/>. [Nazaj](#)

Obrazec: ARRS-RPROJ-ZP/2015 v1.00a

44-25-10-3C-B6-47-C1-06-81-8F-43-DD-13-57-7D-8B-CF-A4-E2-01

## **Priloga 1**

**Graphs in Geometry and Algorithms  
(EuroGIGA)**

**GReGAS Mid-term Report**

**Submission deadline: 11 JANUARY 2013**

**Important :**

- Part A1 of the form is to be completed by the Project Leader. Part A2 is to be completed by each Principal Investigator, including the Project Leader, and each Associated Partner.
- Part B of the form, provided separately, is to be completed by the Project Leader with input from the CRP members.
- The Project Leader should return the completed form (Part A and Part B combined) to ESF in a single Word (.doc) document.

**Part A. General information on the CRP and personnel**

**A.1. Overview of the CRP**

<b>CRP Number:</b>	10-EuroGIGA-FP-007
<b>CRP Title and Acronym:</b>	Geometric representations and symmetries of graphs, maps and other discrete structures and applications in science (GReGAS)
<b>Project Leader (PI 1):</b>	Professor Tomaž Pisanski, Slovenia
<b>Principal Investigator 2:</b>	Professor Vladimir Batagelj, Slovenia
<b>Principal Investigator 3:</b>	Professor Türker Biyikoglu, Turkey
<b>Principal Investigator 4:</b>	Professor Sandi Klavžar, Slovenia
<b>Principal Investigator 5:</b>	Professor Antoaneta Klobucar, Croatia
<b>Principal Investigator 6:</b>	Professor Dragan Marusic, Slovenia
<b>Principal Investigator 7:</b>	Professor Martin Škoviera, Slovak Republic
<b>Principal Investigator 8:</b>	Professor Peter F. Stadler, Germany
<b>Associated Partner 1:</b>	Professor Leah Berman, United States
<b>Associated Partner 2:</b>	Professor Marston Conder and Dimitri Leemans, New Zealand
<b>Associated Partner 3:</b>	Professor Patrick Fowler, United Kingdom
<b>Associated Partner 4:</b>	Professor Wilfried Imrich, Austria
<b>Associated Partner 5:</b>	Professor Mikhail Klin, Israel
<b>Associated Partner 6:</b>	Professor Egon Schulte, United States
<b>Associated Partner 7:</b>	Professor Josef Leydold, Austria

**CRP start and end dates:** 01/04/2011 – 01/04/2014

**CRP website:** <http://www.gregas.eu>

**Topics of the Call for Proposals addressed by the CRP**

Please list the main topics of the Call for Proposals addressed by the CRP.\*

(i) Drawing graphs

(ii) Geometric representations of graphs



**(v) Graphs of polytopal structures**

\* Refer to the text of the Call for Proposals which has been provided to you.

**A2. Individual Projects (IPs) / Associated Projects (APs)**

**Principal Investigator:** Please highlight any changes or corrections to the details below

**Professor Tomaž Pisanski**

Department of Technology  
Faculty of Mathematics and Physics  
University of Primorska  
Muzejski trg 2  
6000 Koper  
Slovenia  
Tel:  
Email: tomaz.pisanski@fmf.uni-lj.si

**Amount of funding granted:** 340000 Euros (due to austerity measures, the budget was reduced by approx 11%)

**IP start and end date:** 01/07/2011 – 30/6/2014

**IP website:** <http://www.gregas.eu>

**Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)****Keywords in relevance to the role of the PL and main topics of the Call for Proposals:**

- (i) Drawing graphs: maps and configurations in the plane and other surfaces, chemical graphs
- (ii) Geometric representations of graphs: maps, symmetric configurations, coherent representation theory, chemical graphs, unit distance graphs, incidence geometries,
- (v) Graphs of polytopal structures : polyhedral maps, abstract polytopes, symmetries, classification

**Scientific & technical personnel involved in the Individual Project (IP)****Personnel directly funded under the CRP budget**

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

- Bauer Andrej, researcher, University of Ljubljana, (since 1.7.2011), 2.5%
- Boben Marko, researcher, Abelium d.o.o. (since 1.7.2011), 5%
- Cvetko Vah Karin, researcher, University of Ljubljana, (since 1.7.2011), 5%
- Chen Hao, researcher, Abelium d.o.o., (1.7.2011 - 31.12.2011), (1.7.2011 - 31.12.2011), 23%
- Grašič Katja, researcher, Abelium d.o.o.(1.1.2011- 31.12.2011), 2.5%
- Horvat Boris, researcher, Abelium d.o.o. (since 1.7.2011), 5%
- Jaklič Gašper, researcher, University of Ljubljana (since 1.7.2011), 5%
- Kavkler Iztok, researcher, Abelium d.o.o. (since 1.7.2011), 17%
- Konvalinka Matjaž, researcher, University of Ljubljana (since 1.7.2011), 10%
- Orbanić Alen, researcher, University of Ljubljana (since 1.7.2011), 50%

- Petkovšek Marko, researcher, University of Ljubljana (since 1.7.2011), 2.5%
- Pisanski Tomaž, researcher, University of Ljubljana (since 1.7.2011), 40%
- Plestenjak Bor, researcher, University of Ljubljana (since 1.7.2011), 5%
- Potočnik Primož, researcher, University of Ljubljana (since 1.7.2011), 2.5%
- Ravnikar Martin, researcher, University of Primorska, Koper, 20%
- Žitnik Arjana, researcher, University of Ljubljana (since 1.7.2011), 15%
- Gašper Košmrlj, PhD student, Abelium d.o.o. (since 1.1.2012), 7.5%

**Personnel funded through sources other than the CRP budget**

(Name, position, nature of involvement)

- Nino Bašič, young researcher, PhD student, University of Primorska
- Katja Berčič, young researcher, PhD student, University of Primorska
- Gabriel Verret, postdoc researcher, University of Primorska
- Ajda Korošec, young researcher, PhD student, University of Primorska
- Boštjan Kovač, young researcher, PhD student, Abelium d.o.o.

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Principal Investigator:** *Please highlight any changes or corrections to the details below*

**Professor Vladimir Batagelj**

Faculty of Mathematics and Physics

University of Ljubljana

Jadranska 19

1000 Ljubljana

Slovenia

Email: vladimir.batagelj@fmf.uni-lj.si

**Amount of funding granted:** 0 Euros (included under PI Pisanski)

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** <http://www.gregas.eu>, <http://vlado.fmf.uni-lj.si/>

**Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)**

**Keywords in relevance to the role of the PI and main topics of the Call for Proposals:**

(i) Drawing graphs: large network visualization and analysis, structure of large network, decomposition, evolution of networks

(ii) Geometric representations of graphs: hierarchical representations, chemical and real life networks representation

(v) Graphs of polytopal structures: /

**Scientific & technical personnel involved in the Individual Project (IP)**

**Personnel directly funded under the CRP budget**

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

- Batagelj Vladimir, PI, researcher, University of Ljubljana (since 1.7.2011), 33%
- Zaveršnik Matjaž, researcher, University of Ljubljana (since 1.7.2011), 10%

**Both researchers are funded through the funds of PL Pisanski.**

**Personnel funded through sources other than the CRP budget**

(Name, position, nature of involvement)

- Monika Cerinšek, young researcher, PhD student, Abelium d.o.o.
- Jernej Bodlaj, young researcher, PhD student, Abelium d.o.o.

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Principal Investigator:** *Please highlight any changes or corrections to the details below*

### Professor Türker Biyikoglu

Faculty of Arts and Sciences  
Department of Mathematics  
Isik University  
Sile 34980  
34980 Istanbul  
Turkey  
Email: turker.biyikoglu@isikun.edu.tr

**Amount of funding granted:** 62200 Euros

**IP start and end date:** 01/09/2011 – 1/9/2014 (temporary stop 1/5/2012 - 31/12/2012)

**IP website:** <http://math.isikun.edu.tr/turker/>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

#### Keywords in relevance to the role of the PI and main topics of the Call for Proposals:

- (i) Drawing graphs: /
- (ii) Geometric representations of graphs: near products, geometry and eigen vectors, landscapes, nodal domains, degree sequence of geometric graphs
- (v) Graphs of polytopal structures: /

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

- Türker Biyikoglu, researcher, Isik University (since 1.9.2011)

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

- /

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Principal Investigator:** *Please highlight any changes or corrections to the details below*

### Professor Sandi Klavžar

Faculty of mathematics and physics  
Department of Mathematics  
University of Ljubljana  
Jadranska 19  
1000 Ljubljana  
Slovenia  
Email: sandi.klavzar@fmf.uni-lj.si

**Amount of funding granted:** 0 Euros (included under PI Pisanski)

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** <http://www.gregas.eu>, <http://www.fmf.uni-lj.si/~klavzar/>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

#### Keywords in relevance to the role of the PI and main topics of the Call for Proposals:

- (i) Drawing graphs: drawing using decomposition to factors, drawing factor graphs
- (ii) Geometric representations of graphs: embedding into graph products, isometric embedding into partial cubes, fibonacci dimension of graph, 2-sum graphs, chemical graphs
- (v) Graphs of polytopal structures: /

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

- Jakovac Marko, researcher, University of Maribor (since 1.1.2012), 6%
- Taranenko Andrej, researcher, University of Maribor (since 1.7.2011), 10%
- Vesel Aleksander, researcher, University of Maribor, (since 1.7.2011) 2%
- Klavžar Sandi, researcher, University of Maribor, (since 1.7.2011) 7%
- Kovše Matjaž, researcher, University of Maribor, (1.7.2011 - 31.7.2011), 4%
- Janja Jerebic, researcher, University of Maribor (1.7.2011 - 31.7.2011), 1%
- Cabello Justo Sergio, researcher, University of Ljubljana (since 1.7.2011), 10%

In 2013 the following member will be included:

- Drago Bokal, researcher, University of Maribor (since 1.1.2013), 6%

#### Researchers are funded through the budget of PL Pisanski.

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

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## A2. Individual Projects (IPs) / Associated Projects (APs)

**Principal Investigator:** *Please highlight any changes or corrections to the details below*

### Professor Antoaneta Klobucar

Department of Mathematics  
 University J.J.Strossmayer  
 GajevTrg 6  
 31000 Osijek  
 Croatia  
 Email: aneta@efos.hr

**Amount of funding granted:** 108000Euros

**IP start and end date:** 01/05/2011 – 30/04/2014

**IP website:** <http://oliver.efos.hr/~aneta/indexhrv.html>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

#### Keywords in relevance to the role of the PI and main topics of the Call for Proposals:

- (i) Drawing graphs: centrality measures in networks, edge betweenness centrality
- (ii) Geometric representations of graphs: representation of large networks, highly and almost symmetric graphs
- (v) Graphs of polytopal structures: representation of maps and polytopes, almost symmetric graphs

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

- Antoaneta Klobučar, researcher, University of Osijek, Croatia (since 1.5.2011), 40%
- Snježana Majstorović, researcher, University of Osijek, Croatia (since 1.5.2011), 10%
- Ivona Puljić, researcher, University of Osijek, Croatia (since 15.6.2011), 10%
- Damir Vukičević, researcher, University of Split, Croatia (since 1.5.2011), 30%
- Jelena Sedlar, researcher, University of Split, Croatia (since 1.5.2011), 8%
- Tanja Vojković, researcher, University of Split, Croatia (since 1.5.2011), 2%

<p><b>Personnel funded through sources other than the CRP budget</b> (Name, position, nature of involvement)</p> <ul style="list-style-type: none"><li>• Ante Graovac, researcher (retired) - remark: prof.dr. Graovac died in December 2012.</li></ul>

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Principal Investigator:** *Please highlight any changes or corrections to the details below*

### Professor Dragan Marusic

Faculty of Mathematics, Natural Sciences and Information Technologies  
University of Primorska  
Glagoljaška 8  
6000 Koper  
Slovenia  
Email: dragan.marusic@upr.si

**Amount of funding granted:** 260000Euros

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** <http://www.famnit.upr.si/sl/zaposleni-in-sodelavci/dragan.marusic/>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

#### Keywords in relevance to the role of the PI and main topics of the Call for Proposals:

- (i) Drawing graphs: /
- (ii) Geometric representations of graphs: symmetric graph, symmetric graphs and configurations
- (v) Graphs of polytopal structures: graph covering algorithms, symmetric graphs and maps, symmetric torusenes, structures in partial geometries

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

- Dobson Edward Tauscher, researcher, University of Primorska (since 1.7.2011), 15%
- Kovacs Istvan, researcher, University of Primorska (since 1.7.2011), 18%
- Malnič Aleksander, researcher, University of Ljubljana (since 1.7.2011), 7%
- Marušič Dragan, PI, researcher, University of Primorska (since 1.7.2011), 10%
- Miklavič Štefko, researcher, University of Primorska (since 1.7.2011), 7%
- Milanič Martin, researcher, University of Primorska (since 1.7.2011), 20%
- Šparl Primož, University of Ljubljana (since 1.7.2011), 7%

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

- Rok Požar, young researcher (PhD student), University of Primorska
- Frelj Boštjan, researcher, University of Primorska
- Dragan Stevanović, researcher, University of Primorska
- Klavdija Kutnar, post doc researcher, University of Primorska
- Vito Vitrih, researcher, University of Primorska
- Enes Pašalić, researcher, University of Primorska



## A2. Individual Projects (IPs) / Associated Projects (APs)

**Principal Investigator:** *Please highlight any changes or corrections to the details below*

### Professor Martin Škoviera

Department of Computer Science  
 Faculty of Mathematics, Physics and Informatics  
 Comenius University  
 Mlynskadolina  
 842 48 Bratislava  
 Slovak Republic  
 Email: [skoviera@dcs.fmph.uniba.sk](mailto:skoviera@dcs.fmph.uniba.sk)

**Amount of funding granted:** 72000Euros

**IP start and end date:** 01/05/2011 – 30/04/2014

**IP website:** [http://new.dcs.fmph.uniba.sk/index.php/Zamestnanci?\\_method=detail&id=17](http://new.dcs.fmph.uniba.sk/index.php/Zamestnanci?_method=detail&id=17)

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

#### Keywords in relevance to the role of the PI and main topics of the Call for Proposals:

- (i) Drawing graphs:
- (ii) Geometric representations of graphs: graph embeddings and immersions, graph colourings, flows, configurations
- (v) Graphs of polytopal structures: highly symmetric maps, enumeration, generating functions, group representations, covering spaces

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

- Martin Škoviera, PI, researcher, Comenius University (since 1.5.2011), 15%
- Roman Nedela, researcher, Mathematical Institute, Slovak Academy of Science (since 1.5.2011), 15%
- Jozef Širáň researcher, Slovak University of Technology (since 1.5.2011), 15%
- Ján Karabáš, researcher, Mathematical Institute, Slovak Academy of Science (since 1.5.2011), 10%
- Edita Rollová, Ph.D student, Comenius University (since 1.5.2011), 10%
- Michal Kotrbčík, Ph.D student, Comenius University (since 1.5.2011), 10%
- Róbert Lukočka, post doc researcher, Comenius University (since 1.5.2011), 10%
- Ján Mazák, post doc researcher, Comenius University (since 1.5.2011), 10%
- Edita Máčajová, researcher, Comenius University (since 1.5.2011), 10%
- Martin Mačaj, researcher, Comenius University (since 1.5.2011), 10%
- Jana Šiagiová, researcher, Slovak University of Technology (since 1.5.2011), 10%
- Ľubica Staneková, post doc researcher, Slovak University of Technology (since 1.5.2011), 10%
- Martin Knor, researcher, Slovak University of Technology (since 1.5.2011), 10%
- Mária Ždimalová, researcher, Slovak University of Technology (since 1.5.2011), 10%

<p><b>Personnel funded through sources other than the CRP budget</b> (Name, position, nature of involvement)</p> <ul style="list-style-type: none"><li>• Imrich Vrto, researcher, Mathematical Institute, Slovak Academy of Science (since 1.5.2011), 10%</li></ul>	

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Principal Investigator:** *Please highlight any changes or corrections to the details below*

### Professor Peter F. Stadler

Department of Computer Science / Bioinformatics  
 Faculty of mathematics and Computer Science  
 University of Leipzig  
 Haertelstrasse 16-18  
 04107 Leipzig  
 Germany  
 Email: peter.stadler@bioinf.uni-leipzig.de

**Amount of funding granted:** 229680Euros

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** <http://www.bioinf.uni-leipzig.de/~studla/>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

#### Keywords in relevance to the role of the PI and main topics of the Call for Proposals:

- (i) Drawing graphs: energy functions
- (ii) Geometric representations of graphs: combinatorial landscapes, chemical graphs, graphs in molecular biology, hierarhically organized graphs, phenotype graphs, cycle sets, cycle space
- (v) Graphs of polytopal structures: /

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

- Matjaž Kovše, post doc researcher (01.03.2012 - 31.08.2012 and 01.10.2012 - 28.02.2013), 100%
- Lia Moheb, researcher (01.01.2013 - 31.01.2013), 50%
- Liliya Avdiyenko, researcher, (01.01.2012 - 28.2.2013), 50%

Remark: funds were not used in 2011 in order to employ postdocs PhD students and the postdoc from 2012 on.

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

- Lydia Ostermeier, PhD student in my group at the MPI MIS, will be financed from GReGAS starting in a few month until the end of the project has been funded by core funding so far. She has contributed primarily to GReGAS with her work on graph and hypergraph products.
- Konstantin Klemm, staff scientist at Univ Leipzig, has been contributing to work on combinatorial landscapes. He has been funded by Univ Leipzig.
- Peter F Stadler, professor, PI, funded by Univ Leipzig
- Marc Hellmuth, researcher at University Saarbruecken, before that staff member in Leipzig, has contributed to work on product structures and has been visiting the Leipzig group several times

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Associated Partner:** *Please highlight any changes or corrections to the details below*

### Professor Leah Berman

University of Alaska Fairbanks  
 Department of Mathematics & Statistics  
 P.O. Box 756660  
 99775 Fairbanks  
 United States  
 Email: lwberman@alaska.edu

**Amount of funding granted:** /

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** /

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

#### Keywords in relevance to the role of the AP and main topics of the Call for Proposals:

- (i) Drawing graphs: /
- (ii) Geometric representations of graphs: geometric configurations, Levi graphs, Astral configurations
- (v) Graphs of polytopal structures: /

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

/

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

- Leah W. Berman, resercher AP

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Associated Partner:** *Please highlight any changes or corrections to the details below*

### Professor Marston Conder and Professor Dimitri Leemans

Department of Mathematics  
University of Auckland  
Private Bag 92019  
92019Auckland  
New Zealand  
Email: m.conder@auckland.ac.nz, d.leemans@auckland.ac.nz

**Amount of funding granted:** /

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** <http://www.math.auckland.ac.nz/~conder/>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

#### Keywords in relevance to the role of the AP and main topics of the Call for Proposals:

- (i) Drawing graphs: /
- (ii) Geometric representations of graphs: /
- (v) Graphs of polytopal structures: regular and chiral maps and polytopes, half-arc transitive graphs, symmetries

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

/

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

- Marston Conder, researcher, AP
- Dimitri Leemans, former PI

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Associated Partner:** Please highlight any changes or corrections to the details below

**Professor Patrick Fowler**

Department of Chemistry  
University of Sheffield  
Western Bank  
Sheffield S3 7HF  
United Kingdom  
Email: p.w.fowler@sheffield.ac.uk

**Amount of funding granted:** /

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** [http://www.sheffield.ac.uk/chemistry/staff/profiles/patrick\\_fowler](http://www.sheffield.ac.uk/chemistry/staff/profiles/patrick_fowler)

**Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)**

**Keywords in relevance to the role of the AP and main topics of the Call for Proposals:**

- (i) Drawing graphs: 3D chemical graph representations
- (ii) Geometric representations of graphs: representations of molecules, chemical graphs, geometric representations, electronic structure
- (v) Graphs of polytopal structures: maps, homo lumo maps, single molecule conduction

**Scientific & technical personnel involved in the Individual Project (IP)**

**Personnel directly funded under the CRP budget**

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

/

**Personnel funded through sources other than the CRP budget**

(Name, position, nature of involvement)

- Patrick W. Fowler, researcher, AP

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Associated Partner:** *Please highlight any changes or corrections to the details below*

### Professor Wilfried Imrich

Department Mathematics and Information Technology  
 Applied Mathematics  
 MontanuniversitaetLeoben  
 Franz Josef-Strasse 18  
 8700 Leoben  
 Austria  
 Email: imrich@unileoben.ac.at

**Amount of funding granted:** /

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** <http://imrich.at/>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

#### Keywords in relevance to the role of the AP and main topics of the Call for Proposals:

- (i) Drawing graphs: visualization through product graphs
- (ii) Geometric representations of graphs: product graphs, graph data structures in C++
- (v) Graphs of polytopal structures: /

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

/

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

- Wilfried Imrich, researcher, AP

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Associated Partner:** *Please highlight any changes or corrections to the details below*

**Professor Mikhail Klin**

Department of Mathematics  
Ben-Gurion University of the Negev  
P.O. Box 653  
84105 Beer-Sheva  
Israel  
Email: klin@cs.bgu.ac.il

**Amount of funding granted:** /

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** <http://www.math.bgu.ac.il/serv/segel/klin.html>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

**Keywords in relevance to the role of the AP and main topics of the Call for Proposals:**

- (i) Drawing graphs: representations with high symmetry,
- (ii) Geometric representations of graphs: symmetric graphs, computer algebra, association scheme, circulant graphs, partial geometries, fullerenes
- (v) Graphs of polytopal structures: geometric strongly regular graphs, permutation groups

### Scientific & technical personnel involved in the Individual Project (IP)

**Personnel directly funded under the CRP budget**

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

/

**Personnel funded through sources other than the CRP budget**

(Name, position, nature of involvement)

- Mikhail Klin, researcher, AP



## A2. Individual Projects (IPs) / Associated Projects (APs)

**Associated Partner:** Please highlight any changes or corrections to the details below

**Professor Egon Schulte**

Department of Mathematics

Northeastern University

567 Lake Hall

MA 02169 Boston

United States

Email: [schulte@neu.edu](mailto:schulte@neu.edu)

**Amount of funding granted:** /

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** <http://www.math.neu.edu/~schulte/>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

**Keywords in relevance to the role of the AP and main topics of the Call for Proposals:**

(i) Drawing graphs:

(ii) Geometric representations of graphs: polygonal complexes, incidence geometries

(v) Graphs of polytopal structures: graph in polyhedra and complexes, chiral polytopes, graphs derived from polytopes

### Scientific & technical personnel involved in the Individual Project (IP)

**Personnel directly funded under the CRP budget**

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

/

**Personnel funded through sources other than the CRP budget**

(Name, position, nature of involvement)

- Egon Schulte, researcher, AP

## A2. Individual Projects (IPs) / Associated Projects (APs)

**Associated Partner:** *Please highlight any changes or corrections to the details below*

**Professor Josef Leydold**

Wirtschaftsuniversität Wien

Institute for Statistics

and Mathematics

Augasse 2-6

A-1090 Vienna

Austria

Email: josef.leydold@wu.ac.at

**Amount of funding granted:** /

**IP start and end date:** 01/07/2011 – 30/06/2014

**IP website:** [http://www.wu.ac.at/statmath/en/faculty\\_staff/faculty/jleydold](http://www.wu.ac.at/statmath/en/faculty_staff/faculty/jleydold)

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

**Keywords in relevance to the role of the AP and main topics of the Call for Proposals:**

(i) Drawing graphs: /

(ii) Geometric representations of graphs: spectral graph theory, cycle structures of graphs, near Cartesian products, near strong products, most appropriate graph products

(v) Graphs of polytopal structures: /

### Scientific & technical personnel involved in the Individual Project (IP)

**Personnel directly funded under the CRP budget**

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

/

**Personnel funded through sources other than the CRP budget**

(Name, position, nature of involvement)

- Josef Leydold, researcher, AP

## Part B. Progress report

### B1. CRP progress and scientific highlights (max. 1500 words)

#### 1. The collaborative work (c.400-750 words)

- a. With reference to the CRP objectives and work plan, describe the work undertaken by the CRP to date and the contribution of each Individual Project to the collaboration in terms of its specific expertise and tasks/responsibilities. How closely are the partners working together?

##### (PL and PI 1, Pisanski)

- Using knowledge of Vega, Encyclopedia of Graphs was established. Several algorithms are implemented.
- Theory of maps (type graphs) was extended and used on chemical graphs. Three dimensional toroids were classified according to symmetries. Edge transitive maps were further studied.
- Geometric representations for curves studied. Graph representation in chemical graph theory and quantum mechanics approaches with further applications were studied.

##### (PI 2, Batagelj)

- Algorithms and visualization methods within the library net.Plexor were developed.
- Extensive analysis of scientific collaboration database ZENTRALL BLATT for mathematics was carried out.
- Evolution networks were studied.

##### (PI 3, Biyikoglu)

- Characterizing connected graphs with given number of vertices and edges which achieve minimum algebraic connectivity. Addressing AGX-system conjecture from 2005.
- Study and solution of power allocation and partner selection polices problems solved in wireless networks, optimal algorithms.
- Study of molecular dendrimers, spectral radius, maximum Collatz–Sinogowitz index.

##### (PI 4, Klavzar)

- Study of Hamming dimension of a graph, Sierpinski graphs; the structure of Fibonacci cubes
- Sierpinski graphs were compared with Hanoi graphs w.r.t. their spanning embeddings
- Metric invariants were investigated, including distance polynomial functions, Wiener index in weighted graphs, and metric dimension of graphs (papers submitted)
- Convexity was investigated, especially the extremal properties of convex cycles.

##### (PI 5, Klobucar)

- *Large networks*: Wiener index and edge decomposition, eccentric connectivity index
- *Graph representations in mathematical chemistry and bioinformatics*:  $\pi$ -electron currents, conjugated circuits, forcing number, upper and lower bounds on bond incident degree indices. Bond additive modelling. Atom bond connectivity index. K-domination on Hexagonal Catus Chains

##### (PI 6, Marusic)

- *Study of Hamilton paths/cycles in cubic*: Cayley graphs arising from certain groups; graph covers; connectivity of distance balanced graphs.
- *Classification of highly symmetric graphs*: cubic symmetric trirculants and tetraculants, bicyclic graphs with extremal values of PI-index, automorphism groups of rational circulant graphs.
- Applications in cryptography, geometric representations

##### (PI 7, Škovič)

- *Graphs embeddings and immersions and highly symmetric maps*. work on classification of certain

types of groups and related embeddings/maps into surfaces, 2-groups, complete bipartite graph embeddings, regular maps with nilpotent automorphism groups, embeddings of n-dimensional cube graphs, construction of self-dual and self-Petrie regular maps, asymptotic formulas for certain classes of maps, relation between genus and cycle space,

- *Colourings, flows and configurations*. Sufficient condition in terms of point-line configurations for a Steiner triple system to be universal derived. Optimal acyclic edge-colourings of cubic graphs are described. Various structural properties of snarks are studied

#### **(PI 8, Stadler)**

- Exploration of connection between the geometric graph models of molecules and polymers and the graphs that represent the relationships among them; minimum cycle bases for graph products. New convex cycle bases introduced.
- A survey about hypergraph products has been published. In the theory of landscapes it has been shown how redundant non-invertible encodings in hard combinatorial optimization problems enhance optimization by enriching the density of low-energy states.
- An efficient heuristic for solving a problem of constructing alternative local multiple sequence alignments from a collection of local pairwise alignments has been developed.
- Graphs that are retracts of Cartesian products of chordal graphs have been characterized. R-retractions, R-cores, and R-cocores of graphs have been studied.

#### **(AP 1, Berman)**

- Developing new techniques for construction of configurations. Investigating monodromy groups of small polyhedra.

#### **(AP 2, Conder/Leemans)**

- Work on regular covers (with Malnic from team of PI Marušič); Symmetric and semi-symmetric 3-valent graphs of small order (with Potocnik from PI Pisanski); GI-graphs (with PI Pisanski and team member Zitnik); Regular maps on surfaces (with Siran from PI Skoviera); Regular and chiral maps with Leemans and cooperation with UNAM, Mexico.
- implementation of algorithms in Magma kernel, study of specific groups and related abstract, enumeration of chiral 3-polytopes of Suzuki groups, building atlases of chiral polytopes, studying rang 2 coset geometries arising from edge-transitive bipartite graphs, development of algorithms for finding apartments in coset geometries, studying of locally 2-arc-transitive complete bipartite graphs.

#### **(AP 3, Fowler)**

- Progress on single-molecule conduction. Shorter note on the conducting properties of fullerenes (conductivity). Relationships between the various graph theoretical conjugated circuit models. Using purely graph theoretical models to the explicitly quantum mechanical approaches used by chemists and physicists (Jahn-Teller graphs).
- Elected to Royal Society.

#### **(AP 4, Imrich)**

- Attended CSASC 2011 in Krems, SODO 2012 and CSD 6 networking activities. Published book together with PI Klavzar. Work on recognition of products and near products (AP Leydold, PIs Stadler, Klavzar)

#### **(AP 5, Klin)**

- IN 2012 spent 3 weeks at Slovakia. Worked with Gyurki (from PI Skoviera). Discovery of families of certain association schemes by using computation algebra.

#### **(AP 6, Schulte)**

- Work on chiral polytopes and graph representations of abstract polytopes.

#### **(AP 7, Leydold)**

- Study of molecular dendrimers, spectral radius, maximum Collatz–Sinogowitz index, connected

- graphs and minimum algebraic connectivity, AGX-system conjecture (see also entries of Biyikoglu)
- Work on cycle bases for graph products, convex cycle base introduced (see also cooperation with PI Stadler).

## 2. Scientific highlights (c.400-750 words)

- Describe the scientific highlights and main achievements of the CRP to date. What has been the most significant/valuable contribution to knowledge so far (e.g. results, breakthroughs)?

### (PI Pisanski)

- prof. Pisanski elected into Academia Europaea, published a book on Configurations. Team released Encyclopedia of graphs (<http://atlas.gregas.eu/>)
- The journal Ars Mathematica Contemporanea indexed by SCI since 2011 (IF=0,4)
- All equivelar 4-toroids classified. Generalized Petersen graphs are unit-distance graphs. Edge-transitive maps of small genus classified. Type graphs of maps applied in chemistry. Link between graph theory and Jahn-Teller theorem established.

### (PI 2 Batagelj)

- New algorithms for network analysis implemented (net.Plexor library, edge clustering, network multiplication, etc.)
- Paper on analysis of scientific collaboration accepted (with PhD student M. Cerinsek).

### (PI 3 Biyikoglu)

- Significant progress on minimum algebraic connectivity and related AGX-system conjecture (with AP Leydold).
- Proved: polymeric molecules dendrimers have maximum spectral radius among all chemical trees (with AP Leydold).
- Solved power allocation and partner selection policies problems in wireless networks; constructed optimal algorithms based on matching theory.

### (PI 4 Klavzar)

- The Hamming dimension of a graph introduced, bounds provided for the dimension of Sierpinski graphs. The canonical isometric representation explicitly described.
- Proved: Wiener index of a weighted graph can be expressed as the sum of the Wiener indices of weighted quotient graphs with respect to an arbitrary combination of Djokovic-Winkler-classes. Cut method can be used to compute an arbitrary distance moment of graphs isometrically embeddable into Cartesian products of triangles.
- An upper bound for the number of convex cycles in a given graph derived. Equality holds if and only if the graph is an even cycle or a Moore graph.

### (PI 5 Klobucar)

- Several applications of graph theory in chemistry, bioinformatics, optimization, organization and analyzing of communication networks, etc. 17 articles published in journals, 1 article in a book.

### (PI 6 Marusic)

- Classified cubic symmetric trirculants, tetraculants and automorphism groups of rational circulant graphs; Bicyclic graphs with extremal values of PI index.
- Prestigious publication in Proc. Lond. Math. Soc on Hamilton Cycles of Cayley graphs.
- New results on connectivity of bipartite distance-balanced graphs.

### (PI 7 Škovič)

- Classification and enumeration of 2-groups that factorise as a product of two cyclic groups with application on regular embeddings of bipartite graph.
- Classification regular maps:

- on non-orientable genus  $3p+2$  ( $p$  odd prime),
- of  $n$ -dimensional cube graphs ,
- with automorphism group nilpotency class 2.
- Construction: infinite classes or regular maps that are both self-dual and self-Petrie-dual
- Asymptotic formulas for counting oriented and the number of reflexible maps; almost all maps are irreflexible.
- Matching numbers of intersection graphs of bases is characterized.
- Optimal acyclic edge-colourings of cubic graphs are described.
- Progress towards 6-decompositions of snarks has been made.

**(PI 8 Stadler)**

- An explicit construction of a minimum cycle bases for the lexicographic product of graphs  $G$  and  $H$ .
- Redundant non-invertible encodings in hard combinatorial optimization problems enhance optimization by enriching the density of low-energy states.
- An efficient heuristic for constructing alternative local multiple sequence alignments from a collection of local pairwise alignments developed, tested.
- Retracts of Cartesian products of chordal graphs characterized.
- 13 publications (submitted, accepted or published), 1 book chapter. Work presented at several international conferences.

**(AP 1, Berman)**

- New infinite classes of symmetric 3-configurations, new construction techniques developed.

**(AP 2 Conder/Leemans)**

- Determination of:
  - the smallest regular polytopes of any given rank;
  - all symmetric 3-valent graphs on up to 10,000 vertices
  - all regular maps of Euler characteristic  $-2$  to  $-600$ , and all regular maps (and all chiral rotary maps) with up to 1000 edges
  - all regular and chiral polytopes with up to 1000 flags
- Construction of families of kaleidoscopic regular maps with trinity symmetry
- Development of new methods for finding all symmetric regular covers of a symmetric graph, and their application to various graphs
- local  $s$ -transitivity test developed in Magma kernel,
- Ree groups in characteristic 3 have only abstract regular polytopes of rank 3
- counted the number of chiral polytopes of rank three for a Suzuki group
- built up two atlases of chiral polytopes
- designed a new algorithm to find apartments in coset geometries

**(AP 3 Fowler)**

- Elected as a Fellow of the Royal Society (FRS).
- Established the mathematical background for definition of omniconducting graphs, chemical applications, conducting properties of fullerenes
- Successful use of purely graph theoretical models in quantum mechanical approaches.

**(AP 4 Imrich)**

- book published : Handbook of product graphs
- elected as a member of Academia Europea, section Informatics

**(AP 5 Klin)**

- 4 new infinite families of non-Schurian association schemes on  $2p^2$  vertices,  $p$  an odd prime
- new infinite family of non-Schurian association schemes with 3 classes, which are invariant with respect to a suitable transitive action of groups  $PSL(2, q)$ ,  $q$  is a prime-power.

**(AP 6 Schulte)**

- proved algebraic and combinatorial conditions for a polytop  $P$  that ensure action of automorphism on  $k$ -arcs of medial layer graph is transitive. Example families provide.

**(AP 7, Leydold)**

- see first two entries under PI Biyikoglu (joint work).
- new concept of convex cycle bases introduced and studied (with PI Stadler)

b. List up to five of your CRP's most significant joint publications(i.e. involving co-authors from at least two IPs in your CRP or co-authors from otherCRPs in the programme).

1. **Horvat, Boris and Kratochvil, Jan and Pisanski, Tomaz. On the computational complexity of degenerate unit distance representations of graphs. in Combinatorial algorithms, Lecture Notes in Comput. Sci. Vol. 6460. Springer, Heidelberg, 2011, 274--285**
2. \*Biyikoglu, Turker and Leydold, Josef, Dendrimers are the unique chemical trees with maximum spectral radius. MATCH 68(2012), 851--854.
3. **\*Sergio Cabello, Jean Cardinal, Stefan Langerman, The Clique Problem in Ray Intersection Graphs, Algorithms – ESA 2012, Lecture Notes in Computer Science Volume 7501, 2012, pp 241-252**
4. \*Conder, Marston and Nedela, Roman and Siran, Jozef, Classification of regular maps of Euler characteristic  $\leq -3p$ . J. Combin. Theory Ser. B 102 (2012), 967--981. <http://dx.doi.org/10.1016/j.jctb.2011.11.003>
5. A. Ceulemans, E. Lijnen, P.W. Fowler, R.B. Mallion, T. Pisanski : Graph Theory and the Jahn-Teller theorem, Proc. Roy. Soc. A 468 (2012) 971-989. DOI: 10.1098/rspa.2011.0508

## B.2. Integration of the CRP in the programme (300-600 words)

1. Describe the contribution of your CRP to the EUROCORES programme. What is the place and role of the CRP in the framework of the programme? From a scientific perspective, how well integrated is your CRP in the programme? How would you describe the intensity of interaction between your CRP and other CRPs in the programme?

Our impression is that CRPs collaborate well. Of course, the cooperation can further improve. Networking events contribute the most. GReGAS CRP is established on the basis of long term EU and worldwide cooperation established around Slovenian, Austrian and Slovak graph theory cores. The coherence of the related network is based on strong personal and long term research relationships and periodic series of the conferences (every four years) with International conference of graph theory in Bled (Slovenia) GEMS workshops (Slovak Republic), SODO series (New Zealand) and other conferences filling the remaining year in the four year cycle held in different places (USA, Portugal, Mexico). Strong connections between Austrian and Slovenian groups are kept through Ljubljana-Leoben seminar every year. Recently, establishing the scientific journal *Ars Mathematica Contemporanea* (founding editors and editors-in-chief are PL Pisanski and PI Marušič) this have even strengthened the cooperation and brought it to the next level. GReGAS project is one of the first projects linking the parts of the network working on a common project goals.

Members of our CRP have through Slovak partners strong connection with Czech scientists and through this to the project GraDR. Thus GReGAS has relatively good cooperation established with leaders of GraDR, while connections with other two CRPs are weaker.

In such a setting the four CRPs represent four strong groups and EUROGIGA programme is an excellent choice to enhance cooperation between the groups. Motivated by various applications in sciences and technologies, the topics addressed in EUROGIGA call have high potential of establishing links with industry and other top sciences. Beside the strong scientific team, Slovenian GReGAS team involves also an industrial partner, Abelium company, which is a form of a spin-off from the group of PL Pisanski still keeping strong cooperation, but also rapidly developing in the industrial field. We believe that (possible) applications of theory in technology represent the strong points of EUROGIGA related topics.

We hope the intensity of interaction between CRPs will further increase in the second part of the project. Perhaps it would be a good idea to try to find synergies for application of some FP7 or Horizon 2020 projects.

2. Describe the benefit to your CRP of being part of the EUROCORES programme (e.g. achieving critical mass of expertise, scale and scope, visibility, collaborative opportunities, ideas, etc.).

The main benefits of the EUROCORES programme is additional support for networking events which is an interesting concept providing enhancement mechanism for inter-project cooperation. CRPs itself contribute to better possibilities for work within the CRPs team. We can notice that exchange of young researchers (PhD students, post docs) and visits have increased and hope it will further increase in the second part of the project.

Networking events provide additional conferences and workshops "forcing" together different groups possibly providing "sparks" for new cooperations. So we absolutely support networking mechanisms.



### B.3. Cross-CRP networking, training and dissemination (max. 750 words)

1. Which networking/training/dissemination activities have you or your CRP members participated in? Indicate how many team members participated in each activity.

Kick-off meeting, Paris:

- 2 GReGAS members attended the event

EuroGIGA Minisymposia at CSASC, 25-28 September 2011. Two minisymposia organized:

- **"Algebraic and topological graph theory"**, Organizers: Roman Nedela (Banska Bystrica), Tomasz Pisanski (Ljubljana) - Organized by our CRP
- **"Combinatorics and Graph Theory"**, Organizers: Michael Drmota (Vienna), Jan Kratochvil (Prague), Marc Noy (Barcelona), Oriol Serra (Barcelona)
- 9 GReGAS members attended the event

SODO 2012 - Symmetries of Discrete Objects Conference and MAGMA Workshop, Queenstown, New Zealand, 13-17 February 2012:

- 16 GReGAS members attended the event

EuroGIGA Session in Assisi, on March 22, 2012, Assisi, Italy

- 1 GReGAS members attended the event

Eurogiga Midterm Conference, July 9-13, 2012, Prague, Czech Republic

- 13 GReGAS members attended the event

Computers in Scientific Discovery 6, August 21-25, Portorož, Slovenia

- 25 GReGAS members attended the event

2. **Networking activities.** Describe *the most important networking activity* for your CRP to date (in terms of impact, outcome, creation of synergy and cooperation within or outside the programme).

SODO 2012 - Symmetries of Discrete Objects Conference and MAGMA Workshop, Queenstown, New Zealand, 13-17 February 2012:

- traditional conference, organized every 4 years
- Organized by PL Pisanski (GReGAS) and main organizer GReGAS AP Conder,
- 16 GReGAS members attended the event, 1 GraDR member
- <http://www.math.auckland.ac.nz/~conder/SODO-2012/>
- traditional conference
- 67 participants from all over the world
- several research project/collaboration work on papers started or continued
- contact between GReGAS and GraDR was strengthened

3. **Training activities.** Describe *the most useful training activity* to date (workshop, course, school, etc.) undertaken by senior or junior researchers of your CRP.

- Within SODO 2012 a Magma workshop was organized.
- Two-week Summer school, "Topics in Algebraic graph theory" (Banska Bystrica, Slovakia).
- PhD Summer School in Discrete Mathematics and Symmetries of Graphs and Networks III (Rogla, Slovenia)

4. **Dissemination activities.** Describe the *most valuable dissemination activity (or activities)* your team has undertaken so far, with respect to (i) the scientific community and (ii) the wider public. Describe the outcome and impact of these activities in terms of promoting your field of research and the EUROCORES programme.

Organisation or co-organisation of events:

- 7th Slovenian International Conference on Graph Theory, Bled, Slovenia, 19 – 25 June 2011
- Meeting “Mathematics and Art”, Ljubljana, Slovenija, junij, 2011
- Annual meeting of International academy for mathematical chemistry, Bled, Slovenija, junij 2011
- CSASC 2011, Krems Austria, T. Pisanski, R. Nedela chairing "Algebraic and topological graph theory" session. Also organization of EUROGIGA session.
- SODO 2012, Symmetries of Discrete Objects, Conference and MAGMA Workshop, Queenstown, New Zealand, 13-17 February 2012
- Computers in Scientific Discovery (CSD) conference: CSD6 August 2012, Portorož, SI. This meeting had participants from chemistry, mathematics & computer science, with a strong representation from GREGAS researchers, and invited speakers included Nobel Laureate Sir Harold Kroto, whose seminal work on fullerenes is central to our theme of using graph theoretical ideas in chemical applications.

**Associate partners**

- Royal Society Workshop: Symmetry, Rigidity & Periodicity in Natural & Engineered Structures, Chicheley Hall, Feb. 2012 (P. W. Fowler, initiator and co-organizer)
- Aromaticity, International Conference on Physical Organic Chemistry (ICPOC21), Durham Sept, 2012 (P. W. Fowler, co-organizer)

5. List the cross-CRP activities your CRP has organised or co-organised. If your CRP has not been involved in organising any cross-CRP activity to date, what activities do you intend to propose and organise in the future?

EuroGIGA Minisymposia at CSASC, 25-28 September 2011. GREGAS PL Pisanski and PI Nedela organized one of two EuroGIGA minisymposia:

- **"Algebraic and topological graph theory"**, Organizers: Roman Nedela (Banska Bystrica), Tomasz Pisanski (Ljubljana) - Organized by our CRP
- **"Combinatorics and Graph Theory"**, Organizers: Michael Drmota (Vienna), Jan Kratochvil (Prague), Marc Noy (Barcelona), Oriol Serra (Barcelona)
  - 43 participants.
  - Organizers: GREGAS + GraDR
  - web: <http://www.dmg.tuwien.ac.at/OMG/OMG-Tagung/>

**SODO 2012 - Symmetries of Discrete Objects Conference and MAGMA Workshop, Queenstown, New Zealand, 13-17 February 2012:**

- 67 Participants.
- Organizers: GREGAS + GraDR
- web: <http://www.math.auckland.ac.nz/~conder/SODO-2012/>

**Computers in Scientific Discovery 6, August 21-25, Portorož, Slovenia**

- Scientific committee: Tomaž Pisanski (chair), Patrick Fowler, Klavdija Kutnar.
- Organizing committee: Klavdija Kutnar (chair), Boštjan Frelih, Ademir Hujdurović, Alen

Orbanič, Tomaž Pisanski.

- web: <http://csd6.imfm.si>
- 57 participants

**Future:**

- CSASC 2013, Koper, Slovenia. <http://conferences2.imfm.si/conferenceDisplay.py?confId=14>
- GEMS 2013, Smolenice, Slovakia. <http://univac.savbb.sk:8080/gems13/>

## B.4. Publications, dissemination and outreach

**Important:** In your lists, include only those publications which resulted to a significant extent from work undertaken in the framework of the CRP or from collaboration with other CRPs. Note that all such publications should bear an acknowledgement of the EuroGIGA programme.

### In addition:

- List *all* authors.
- Identify with an asterisk (\*) publications which acknowledge the EUROCORES programme.
- Underline publications/presentations involving co-authors from at least two IPs within your CRP.
- **Mark in bold publications/presentations involving co-authors from other CRPs in the programme.**

### Publications

- Articles

*Peer-reviewed articles in journals (published, in press or submitted)*

Bauer, Andrej, On the failure of fixed-point theorems for chain-complete. Theoret. Comput. Sci. 430 (2012), 43--50. <http://dx.doi.org/10.1016/j.tcs.2011.12.005>

Horvat, Boris and Pisanski, Tomaz and Zitnik, Isomorphism Checking of I-graphs. Graphs Combin. 28 (2012), 823--830. <http://dx.doi.org/10.1007/s00373-011-1086-2>

\*Zitnik, Arjana and Horvat, Boris and Pisanski, All generalized Petersen graphs are unit-distance graphs. J. Korean Math. Soc. 49 (2012), 475--491. <http://dx.doi.org/10.4134/JKMS.2012.49.3.475>

Horvat, Boris and Pisanski, Toma\vz, Unit distance representations of the Petersen graph in the. Ars Combin. 104 (2012), 393--415.

A. Ceulemans, E. Lijnen, P.W. Fowler, R.B. Mallion, T. Pisanski : S5 graphs as model systems for icosahedral Jahn-Teller problems, Theor. Chem. Acc. 131 (2012) Art 1246. DOI: 10.1007/00214-012-1246-3

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## Presentations in scientific meetings

- Oral presentations (indicate invited / keynote talks)

7th Slovenian International Conference on Graph Theory, Bled, Slovenia, June 2011 (majority of project members, invited speakers: Škoviera, Imrich, Schulte)

T. Pisanski. Meeting "Mathematics and Art", Ljubljana, Slovenija, June 2011

T. Pisanski. Workshop on Symmetry in Graphs, Maps, and Polytopes, Toronto, Canada, October 2011 (invited speaker)

T. Pisanski. The 35th Australasian Conference on Combinatorial Mathematics & Combinatorial Computing, Monash University, Melbourne, Australia, December 2011

Batagelj Vladimir, Cerinšek Monika, Horvat Boris: Network analysis of Zentralblatt MATH data. 7th Slovenian

International Conference on Graph Theory, Jun 2011, Bled, Slovenia.

Bodlaj Jernej, Batagelj Vladimir, Orbanić Alen: OpenGL® Graphical User Interface for net.Plexor - Interactive Large Network Analysis Library. 7th Slovenian International Conference on Graph Theory, Jun 2011, Bled, Slovenia.

Batagelj Vladimir, Cerinšek Monika, Horvat Boris, Pisanski Tomaž: Exploring the structure of mathematical publications, CSASC 2011, September 2011, Krems, Austria.

Batagelj Vladimir, Cerinšek Monika, Horvat Boris, Pisanski Tomaž: The structure of mathematics from Zentralblatt MATH data. 16th Young Statisticians Meeting, October 2011, Rijeka, Croatia.

Batagelj Vladimir, Cerinšek Monika, Horvat Boris, Pisanski Tomaž: The structure of mathematics from the Zentralblatt MATH data base. Sunbelt XXXII, March 2012, Redondo Beach, CA, USA.

Breznik Kristijan, Batagelj Vladimir: Network analysis of tennis games in the Open Era. Sunbelt XXXII, March 2012, Redondo Beach, CA, USA.

Sandi Klavžar: Fibonacci cubes, generalized Fibonacci cubes, and bad words, invited plenary talk at Combinatorics 2012, Perugia, Italy, September 2012 (invited talk).

Sandi Klavžar: Generalized Fibonacci cubes and three related problems on binary words, invited plenary talk at The 21st Workshop '3in1', Krakow, Poland, November 2012 (invited talk).

Aleksander Vesel: Linear recognition and embedding of Fibonacci cubes, talk at Combinatorics 2012, Perugia, Italy, September 2012 (invited talk).

Math Chem Comp, Dubrovnik (13.6.-18.6.2011) // Snjezana Majstorovic, Antoaneta Klobucar: K-domination on hexagonal chain cacti (talk)

EuroGiga Midterm Conference, July 2012, Prague, Czech Republic // Snjezana Majstorovic: Domination on m-ary chain cacti (talk)

8th Meeting of the International Academy of Mathematical Chemistry, June 2012, Verona, Italy // Snjezana Majstorovic: Bounds and relations involving betweenness centrality in some families of graphs (talk)

MATH/CHEM/COMP 2011 (Dubrovnik) // Sedlar Jelena, Vukičević Damir, Rajtmajer Sarah Michele, "On ordering alkanes by modified Zagreb indices" //

7th Slovenian International Conference on Graph Theory (Bled, 2011) //D. Vukičević, "Community detection in complex networks"

Dragan Marušič, On two open problems in vertex-transitive graphs, "Beijing International Workshop on Group Actions on Combinatorial Structures", August 21 - 27, 2011, Beijing, China. (INVITED TALK).

Klavdija Kutnar, Classification of cubic symmetric polycirculants, "Beijing International Workshop on Group Actions on Combinatorial Structures", August 21 - 27, 2011, Beijing, China. (INVITED TALK).

Edward Dobson, Which Johnson graphs and folded Johnson graphs are Cayley graphs, "Beijing International Workshop on Group Actions on Combinatorial Structures", August 21 - 27, 2011, Beijing, China. (INVITED TALK).

Dragan Marušič, Searching for snarks amongst Cayley graphs, "CID 2011 Colourings, Independence and Domination 14th WORKSHOP ON GRAPH THEORY" September 18 - 23, 2011, Szklarska Poreba, Poland.

Klavdija Kutnar, Cubic Cayley graphs and snarks, "Workshop on Symmetry in Graphs, Maps, and Polytopes", October 24-27, 2011, the Fields Institute, Toronto, Canada (INVITED TALK).

Dragan Marušič, Half-arc-transitive graphs - possible research directions, "Workshop on Symmetry in Graphs,

Maps, and Polytopes", October 24-27, 2011, the Fields Institute, Toronto, Canada.

Aleksander Malnič, On the Split Structure of Lifted Groups, ``Workshop on Symmetry in Graphs, Maps, and Polytopes", October 24-27, 2011, the Fields Institute, Toronto, Canada .

Klavdija Kutnar, Quasi  $m$ -Cayley strongly regular graphs, ``SODO2012 - Symmetries of Discrete Objects", February 13 - 17, 2012, Queenstown, New Zealand.

Aleksander Malnič, On the split structure of lifted groups, I, ``SODO2012 - Symmetries of Discrete Objects" February 13 - 17, 2012, Queenstown, New Zealand.

Klavdija Kutnar, Cubic Cayley graphs and snarks, International Conference on Cycles in Graphs, Nashville, USA, May 30 - June 2, 2012 (Invited Speaker).

Dragan Marušič, Hamiltonicity of cubic Cayley graphs, International Conference on Cycles in Graphs, Nashville, USA, May 30 - June 2, 2012 (Invited Speaker).

Istvan Kovacs, Characterization of cyclic Schur groups, AAA84 84th Workshop on General Algebra, Dresden, Germany, June 8 - 10, 2012

Klavdija Kutnar, Distance-transitive graphs admit semiregular automorphisms, MDA 2012 - Mathematics of Distances and Applications, Varna, Bulgaria, July 2 - July 5, 2012 (Invited Speaker).

Dragan Marušič, An infinite family of half-arc-transitive graphs with universal reachability relation, MDA 2012 - Mathematics of Distances and Applications, Varna, Bulgaria, July 2 - July 5, 2012 (Invited Speaker).

Aleksander Malnič, On the split structure of lifted groups, I, MDA 2012 - Mathematics of Distances and Applications, Varna, Bulgaria, July 2 - July 5, 2012 (Invited Speaker).

Martin Milanič, Equistable graphs: conjectures, results, and connections with Boolean functions, 25th European Conference on Operational Research, Vilnius (Lithuania), July 8-11, 2012.

Martin Milanič, Uniqueness of independence polynomials in monogenic graph classes, International Colloquium on Graphs and Optimization 2012, Leukerbad, Switzerland, August 13-17, 2012.

7th Slovenian International Conference on Graph Theory 19-25 June 2011, Bled, Slovenia

- Martin Skoviera: Snarks - Recent development (keynote lecture)
- Ján Karabáš: Classification of Edge-transitive Maps Michal Kotrbýček: High-genus Embeddings
- Martin Mačaj: Nonorientable Regular Maps Over Linear Fractional Groups
- Roman Nedela: Asymptotic Enumeration of Reversible Maps Regardless of Genus

23rd British Combinatorial Conference University of Exeter, 4-8 July, 2011.

- Jozef Širáň, Nonorientable regular maps of any given type over linear fractional groups

IWONT 2011 International Workshop on Optimal Network Topologies Brussels, Belgium, July 11 - 15, 2011

- Jana Siagiova: Cayley graphs in the degree-diameter problem (keynote lecture)
- Martin Knor: On 3-arc graphs
- Martin Macaj: Search for properties of the missing Moore graph
- Maria Zdimalova: A family of large vertex-transitive graphs of diameter 2

Group Actions on Combinatorial Structures Beijing, August 21-27, 2011

- Martin Skoviera Regular maps with nilpotent automorphism groups
- Ján Karabáš: Discrete groups of automorphisms of orientable surfaces
- Roman Nedela: Discrete groups of automorphisms of surfaces with given genus
- Jozef Širan: External symmetries of regular maps

Workshop on Symmetry in Graphs, Maps, and Polytopes Fields Institute Toronto, October 24-27, 2011

- Martin Skoviera: Regular maps with nilpotent automorphism groups
- Jan Karabas: Classification of edge-transitive maps
- Martin Macaj: Nonorientable Regular Maps and Residual Finiteness of Triangle Groups
- Roman Nedela: Vertex Transitive and Edge Transitive Polytopes and 2-Dimensional Orbifolds
- Jozef Siran: External Symmetries of Regular and Orientably Regular Maps

AMS Special Session on Topological Graph Theory, Structure and Symmetry, Boston, January 4-7, 2012

- Martin Skoviera: Locally Maximal Embeddings of Graphs in Orientable Surfaces (invited lecture)
- Roman Nedela: A recent progress in map enumerations (invited lecture)
- Roman Nedela: Vertex transitive polyhedral maps and actions of discrete groups on surfaces (invited lecture)

ATCAGC 2012 Workshop on Algebraic, Topological and Complexity Aspects of Graph Covers 26th - 31st January 2012, Eugene, Oregon

- Roman Nedela: Flows and graph coverings

SODO 2012 Symmetries of Discrete Objects Conference and MAGMA Workshop Queenstown, New Zealand, 12-17 February 2012

- Jan Karabas: Discrete group actions on orientable surfaces
- Martin Macaj: On the Wilson operators
- Jozef Siran: Imprimitivity of locally finite, 1-ended, planar graphs

Eurogiga Midterm Conference Prague, July 9-13, 2012

- Martin Skoviera: Regular maps with nilpotent automorphism groups (invited lecture)

IWONT 2012 The 5th International Workshop on Optimal Network Topologies July 27 – 29, 2012 Institut Teknologi Bandung, Indonesia

- Jozef Siran: A survey of algebraic methods in the degree-diameter problem (keynote lecture)
- Martin Knor: Graphs with given degree and diameter on the smallest number of vertices
- Jana Siagiova: Quotients of large vertex-transitive and Cayley graphs of given degree and diameter

ACCOTA 2012 International Workshop Combinatorial and Computational Aspects of Optimization, Topology and Algebra December 3 to 7, 2012. Huatulco, Oaxaca, México

- Martin Skoviera: Odd decompositions of regular eulerian graphs of odd orders
- Jozef Siran: Algebraic methods in the degree-diameter problem

Associate partners

Berman, L. W. Fields Institute Thematic Program on Discrete Geometry and Applications: Workshop on Symmetry in Graphs, Maps and Polytopes, Oct 24 -- 27, 2011,  
<http://www.fields.utoronto.ca/programs/scientific/11-12/discretegeom/talks/october.html>

M. Conder. 'The smallest regular polytopes of each rank'. Presented at 35th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing, Melbourne, Australia, December 2011

M. Conder. 'A new approach to finding covers of arc-transitive graphs'. Presented at Workshop on Algebraic, Topological and Complexity Aspects of Graph Covers (ATCAGC 2012), Eugene, Oregon, USA, January 2012.

M. Conder. 'Finitely-presented groups in MAGMA'. Presented at Conference on Symmetries of Discrete Objects (SODO 2012), Queenstown, New Zealand, February 2012.

M. Conder. 'The orders of symmetric graphs'. Presented at SIAM Conference on Discrete Mathematics, Halifax, Nova Scotia, Canada, June 2012.

M. Conder. 'The intersection condition for regular polytopes'. Presented at Workshop on Abstract Polytopes (WAP 2012),

Cuernavaca, Mexico, July 2012.

M. Conder. 'Graph Symmetries'. Presented at 36th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing (36ACCMCC), Sydney, Australia, December 2012.

P. W. Fowler. Ruđer Bošković Institute, Zagreb, 3 July 2012. Invited lecture in series: Eminentni znanstvenici na IRB (Distinguished Scientists at the RBI) Fries numbers of benzenoids - even faulty algorithms can be interesting (invited talk)

P. W. Fowler. Croatian Academy of Sciences and Arts, Invited lecture 'Aromaticity and counting', November 2012. (invited talk)

P. W. Fowler. Invited contributor to Fields Institute of Mathematics (Toronto) to meeting on mathematical aspects of Rigidity and Symmetry, Oct 2011 (invited talk)

M. Klin. conference SSAOS 2012 (High Tatras) see <https://sites.google.com/site/ssalgebra2012/program>  
Title: New non-Schurian association schemes with a few classes (invited talk)

W. Imrich. 13.-17. February, 2012. SODO 2012, Conference on "Symmetries of Discrete Objects". Queenstown, New Zealand  
Lecture "Distinguishing Infinite Graphs".

W. Imrich. 12. March, 2012, Lecture in Maribor "Distinguishing Infinite Graphs".

W. Imrich. 28.-31. March and 15.-19. April, 2012 (Blocked course, three weeks). AGH Cracow, "The direct product and large networks".

W. Imrich. 4. May till 14. June, 2012 Graph Theory Semester, University of Primorska, Koper, Slovenia  
Lectures on "Symmetry Breaking in Graphs"

W. Imrich. 24.-30. June, 2012. 3rd SYGN Workshop and 2012 PhD Summer School Discrete Mathematics Rogla, Slovenia

W. Imrich. 1.-5. Juli 2012. 6th European Congress of Mathematics, Cracow. Lecture "The endomorphism distinguishing number of graphs".

W. Imrich. 18. September, 2012. Lecture at Renyi Institute of the Academy of Sciences . in budapest on "Symmetry Breaking in Graphs".

W. Imrich. 20. September, 2012. 10 Years Bioinformatics Leipzig

W. Imrich. 1.-3. October 2012. International Symposium on Complex Network Analysis UMIT, Hall in Tirol Lecture on "Networks and Products of Graphs".

W. Imrich. 19. October 2012. Lecture in Klagenfurt "Netzwerke".

W. Imrich. 12. November 2012. Lecture University of Maribor "Symmetry Breaking in Graphs".

W. Imrich. 25. November until 7. December, 2012 (Two-week blocked course) in Cracow on "Symmetry breaking in graphs". (More detailed than in Koper.)

W. Imrich. 21st Workshop '3in1' 2012, Cracow, Poland. 29. November - 1. December 2012. Lecture "On the infinite Motion conjecture for Graphs and Groups".

D. Leemans: Symmetries of Discrete Objects 2012, Queenstown (New Zealand), February 13-17, 2012. Magma Minicourse on Permutation Groups, 2 lectures.



D. Leemans: New Zealand Mathematical Society Colloquium, Auckland (New Zealand), December 6-8, 2011. Polytopes of high rank for the symmetric groups.

D. Leemans: Workshop on Symmetry, Graphs and Polytopes, Fields Institute, Toronto (Canada), October 24-27, 2011. Plenary talk. Polytopes of high rank arising from almost simple groups.

D. Leemans: Seventh Slovenian International Conference on Graph Theory, Bled (Slovenia), June 20-25, 2011. Chirally regular polytopes.

D. Leemans: 5th De Bruin Workshop on Groups, Combinatorics and Computing, NUI Galway (Ireland), April 11-16, 2011. Searching for Geometries with Magma.

Leydold, Josef. 2011. Convex Cycle Bases and Cartesian Products. 25th LL-Seminar on Graph Theory, Leoben, Österreich, 23.09.-24.09.

Leydold, Josef. 2012. Generating Generalized Inverse Gaussian Distributed Random Variates. Monte Carlo and Quasi-Monte Carlo Methods 2012, Sydney, Australien, 13.02.-17.02.

Leydold, Josef. 2011. Convex Cycle Bases. 7th Slovenian International Conference on Graph Theory, Bled, Slowenien, 20.06.-24.06.

#### - Posters

Computers in Scientific Discovery conference, August 2012, Portoroz (Slovenia) // Ivona Puljic: Upper and lower bound for Roman domination number of cardinal product of paths, (which was a joint work with Croatian PI Antoaneta Klobucar)

#### - Other (*please define*)

Balakrishnan, R. and Bapat, R. B. and Klavžar, Sandi and, Preface [Recent trends in graph theory and combinatorics]. Discrete Math. 312 (2012), 1493. <http://dx.doi.org/10.1016/j.disc.2011.12.025> (Introduction)

Bratislava Graph Theory Seminar (Regular seminar on graph theory and combinatorics)  
Head of the seminar: Martin Skoviera Weekly (during the semester) at Comenius University, Bratislava Slovakia

Seminar for Discrete Mathematics, Institute of Mathematics, Physics and Mechanics, Ljubljana. Head of the seminar: Tomaž Pisanski.

Annual meeting of the slovak part of the GReGAS team. December 5 to 12 2011 and December 11 to 15 2012 Mosonmagyaróvár, Hungary

AGT in BB Algebraic Graph Theory in Banská Bystrica, August/September 2012, Matej Bel University, Banská Bystrica Slovakia

- Programme Committee: Mikhail Klin, Roman Nedela and Martin Macaj (all members of GReGAS)
- Organizing Committee: Martin Macaj, Jan Karabas (both GReGAS) and Stefan Gyurki

In addition, Slovenian PL and PI teams achieved the following:

- Organization of the conference Computers in Scientific Discovery with a plenary speaker, prof. Harold Kroto, nobel laureate (discovery of C60 fulleren)
- proj. member prof. Konvalinka received award of University of Ljubljana given to best teachers.
- A project financed by Picker Institute (USA, Colgate University) continued into the 2nd year as the results for the first year were very good.
- Pisanski appointed to the Publications Committee of European Mathematical Society.
- PI prof. Marusic was elected as rector of the University of Primorska.
- project member prof. Miklavic received national award for science (Zois prize).

Unpublished lecture: Leydold, Josef. 2012. Sign patterns of graph laplacian eigenvectors. Istanbul Discrete



Mathematics Meetings, Istanbul, 27.04.

**Public outreach**

## - Press releases

(see below)

## - National / international newspaper articles (presenting your CRP or part of your work)

Article related to the conference and EUROGIGA networking event and especially about nobelist Sir Harald Kroto visiting Slovenia having talk at CSD 6 conference.

- <http://www.dnevnik.si/magazin/znanost-in-tehnologija/1042548265>
- [http://www.primorska.info/novice/18840/nobelovec\\_kroto\\_predaval\\_na\\_turisticih](http://www.primorska.info/novice/18840/nobelovec_kroto_predaval_na_turisticih)
- <http://www.slomedia.it/dr-kroto-znanost-je-predvsem-nacin-razmisljanja>

## - TV appearance

Croatian Academy of Sciences and Arts, Invited lecture 'Aromaticity and counting', November 2012. (invited talk)

Short interview about this second lecture was recorded for Croatian TV

## - Radio appearance

/

- Other (*please define*)

/

**Other activities / outputs**

## - Patents

/

## - Websites

<http://www.gregas.eu> - Official project web site  
<http://atlas.gregas.eu> - Encyclopedia of graphs web site

- Other (please define)

- Abelium team: won Slovenian innovation award for the most innovative service iOliva (geometric graph theory application)

## B.5. Feedback on the EUROCORES programme and EUROCORES scheme

Any other comments on the EUROCORES programme in particular or the EUROCORES scheme in general.

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## **Priloga 2**

**EuroGIGA**

**GReGAS**

**Final report (Sections B and C)**

**Deadline: 1/12/2014**

**Section B. Progress report**

**B1. CRP progress and scientific highlights (max. 1500 words)**

**1. The collaborative work (c.400-750 words)**

- a. With reference to the CRP objectives and work plan, describe the work undertaken by the CRP and the contribution of each Individual Project to the collaboration in terms of its specific expertise and tasks/responsibilities. How closely did the partners work together?

**PI1-Pisanski**

- Encyclopaedia of Graphs was established. Several algorithms developed.
- Theory of maps (type graphs) was extended, used on chemical graphs. Various classes of maps were classified.
- Geometric representations for curves were studied.
- Graph representations in chemical graph theory, quantum mechanics approaches with further applications were studied.

**PI2-Batagelj**

- Algorithms and visualization methods within the libraries net.Plexor, TQ and lanus were developed.
- Extensive analysis of scientific collaboration database ZENTRALL BLATT for mathematics was carried out.
- Dynamic networks were studied.

**PI3-Biyikoglu**

- Classification of graphs achieving minimum algebraic connectivity.
- Study of power allocation and partner selection polices problems in wireless networks, molecular dendrimers, spectral radius, maximum Collatz–Sinogowitz index; relationships between graph invariants; spectral bounds for maximum induced matching problem
- Analysis of metabolic pathways, work on de novo peptide sequencing
- Modeling social communication (anonymity) with graph theory.

**PI4-Klavzar**

- Study of Hamming dimension of a graph, Sierpinski graphs; the structure of Fibonacci cubes
- Sierpinski graphs were compared with Hanoi graphs w.r.t. their spanning embeddings
- Metric invariants were investigated, including distance polynomial functions, Wiener index in weighted graphs, and metric dimension of graphs (papers submitted)
- Convexity was investigated, especially the extremal properties of convex cycles.
- Lambda-labelling of product graphs and related classes were studied.

**PI5-Klobucar**

- *Large networks*: Wiener index and edge decomposition, eccentric connectivity index, social networks
- *Graph representations in mathematical chemistry and bioinformatics*: pi-electron currents, conjugated circuits, forcing number, upper and lower bounds on bond incident degree indices. Bond additive modelling. Atom bond connectivity index. K-domination on Hexagonal Catus Chains
- Roman-dominations on cardinal product of path and cycles studied.

**PI6-Marusic**

- *Study of Hamilton paths/cycles in cubic*: Cayley graphs arising from certain groups; graph covers; connectivity of distance balanced graphs.
- *Classification of highly symmetric graphs*: cubic symmetric trirculants and tetracirculants, bicyclic graphs with extremal values of PI-index, automorphism groups of rational circulant graphs.
- Applications in cryptography, geometric representations

**PI7-Škoviera**

- *Graphs embeddings and immersions and highly symmetric maps*. work on classification of certain types of groups and related embeddings/maps into surfaces, 2-groups, complete bipartite graph embeddings, regular maps with nilpotent automorphism groups, embeddings of n-dimensional cube graphs, construction of self-dual and self-Petrie regular maps, asymptotic formulas for certain classes of maps, relation between genus and cycle space, local maxima in the stratified system of all graph embeddings described.
- *Colourings, flows and configurations*. Sufficient condition in terms of point-line configurations for a Steiner triple system to be universal derived. The existence of 4-line Fano colourings for a very general class of snarks confirmed. Study of snarks, optimal acyclic edge-colourings of cubic graphs.

**(PI 8, Stadler)**

- Exploration of connection between the geometric graph models of molecules and polymers and the graphs that represent the relationships among them
- Survey about hypergraph products has been published.
- Characterization of retracts of Cartesian products of chordal graphs.
- Characterization of recombination on strings as transit function was done.
- A unified framework for linear and circular multiple sequence alignments was established.
- A new formalization of graph editing, relaxed square property and topology of elementary cycles, connective spaces and application is landscape theory were studied.

**(AP 1, Conder/Leemans)**

- Work on regular covers (with PI6); Symmetric and semi-symmetric 3-valent graphs of small order (with PI1); GI-graphs (with PI1); Regular maps on surfaces (with PI7); Regular and chiral maps with Leemans.
- implementation of algorithms in Magma kernel, study of specific groups and related abstract polytopes, various enumeration and generation algorithms for groups, abstract polytopes, apartments and coset geometries..
- Investigation of arc-types of vertex-transitive graphs (with PI1); new discoveries about half-arc-transitive graphs (with PI1 and PI6); investigation of regular maps with nilpotent automorphism groups (with PI7); construction of chiral maps of all possible types (with PI7).

**AP2-Fowler**

- Progress on single-molecule conduction. Short note on the conducting properties of fullerenes (conductivity). Relationships between the various graph theoretical conjugated circuit models. New purely graph theoretical models of quantum mechanical approaches to distortion used by chemists and physicists (Jahn-Teller graphs).
- Elected to Royal Society, citation included work on graph-theoretical modelling of currents.
- New classification by nullity of omni-conductors and insulators. Chemical counterexamples for conjugated-circuit theory.

<p><b>AP3-Imrich</b></p> <ul style="list-style-type: none"> <li>○ Attended CSASC 2011 in Krems, SODO 2012, CSD 6, CSASC 2013 and LL 2014 networking activities. Published book together with PI Klavzar. Work on recognition of products and near products (AP Leydold, PIs Stadler, Klavzar)</li> </ul> <p><b>AP4-Klin</b></p> <ul style="list-style-type: none"> <li>○ IN 2012 spent 3 weeks at Slovakia. Worked with Gyurki (from PI7). Discovery of families of certain association schemes by using computation algebra.</li> <li>○</li> </ul> <p><b>AP5-Schulte</b></p> <ul style="list-style-type: none"> <li>○ Work on chiral polytopes and graph representations of abstract polytopes.</li> </ul>
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## 2. Scientific highlights (c.400-750 words)

- a. Describe the scientific highlights and main achievements of the CRP. What has been the most significant/valuable contribution to knowledge (e.g. results, breakthroughs)?

<p><b>PL-Pisanski</b></p> <ul style="list-style-type: none"> <li>• Professor Pisanski elected into Academia Europaea, published a book on Configurations.</li> <li>• Encyclopedia of graphs released (<a href="http://atlas.gregas.eu/">http://atlas.gregas.eu/</a>)</li> <li>• Database of cubic vertex transitive graphs up to 1280 vertices generated.</li> <li>• The journal Ars Mathematica Contemporanea indexed by SCI since 2011 (IF=0,4)</li> <li>• Classification and characterization: equivelar 4-toroids, generalized Petersen as unit-distance graphs, Edge-transitive maps of small genus. G-laterals of certain configurations. Medial symmetry maps.</li> <li>• Applications: Type graphs in chemistry. Graph theory and Jahn-Teller theorem. Strong traces introduced in synthetic biology, Map representation of DNA. Complex web site organization.</li> </ul> <p><b>PI2-Batagelj</b></p> <ul style="list-style-type: none"> <li>• New algorithms for network analysis implemented (in new libraries: net.Plexor, TQ, lanus)</li> <li>• 3 papers on bibliographic network analysis</li> <li>• Received INSNA's William D. Richards Jr., Software Award (2013) for Pajek</li> </ul> <p><b>PI3-Biyikoglu</b></p> <ul style="list-style-type: none"> <li>• Progress on minimum algebraic connectivity, AGX-system conjecture</li> <li>• Proved: polymeric molecules dendrimers have maximum spectral radius among all chemical trees</li> <li>• New algorithms: power allocation and partner selection polices problems in wireless, de novo sequencing, constrained alignment framework for the comparative analysis of a pair of metabolic pathways</li> <li>• Proved: rigorous relationship between several graph invariants, including entropy, Randic index and degree assortativity.</li> <li>• Graph model for multi party off-the-record communication</li> <li>• Spectral bounds for maximum induced matching</li> </ul> <p><b>PI4-Klavzar</b></p> <ul style="list-style-type: none"> <li>• An upper bound for the number of convex cycles in a given graph derived. Equality holds if and only if the graph is an even cycle or a Moore graph.</li> <li>• Proved that the Wiener index of a weighted graph can be expressed as the sum of the Wiener indices of weighted quotient graphs with respect to an arbitrary combination of Djokovic-Winkler-classes. Cut method can be used to compute an arbitrary distance moment of graphs isometrically embeddable into Cartesian products of triangles.</li> </ul> <p><b>PI5-Klobucar</b></p> <ul style="list-style-type: none"> <li>• Several applications of graph theory in chemistry, bioinformatics, optimization, organization and analysis of communication networks, etc. 17 articles published in journals, 1 article in a book.</li> </ul>
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- Generalised network descriptors were investigated
- Network organization, network analysis and information protection were investigated

#### **PI6-Marusic**

- Classified cubic symmetric trirculants, tetracirculants and automorphism groups of rational circulant graphs; Bicyclic graphs with extremal values of PI index.
- Characterized tetravalent one regular graphs of order  $p^2$ , symmetric Tabáčjn graphs, pentavalent act-transitive bicirculants, half-arc transitive graphs with small alternets, cubic-symmetric tri- and penta-circulants.
- Prestigious publication in Proc. Lond. Math. Soc on Hamilton Cycles of Cayley graphs.
- Several new results related to: connectivity of bipartite distance-balanced graphs, identifiable subgraphs, equistable graphs, threshold and domishold graphs, square roots of graphs, CIS circulants, claw freeness, domination.

#### **PI7-Škoviera**

- Classification and enumeration of 2-groups that factorise as a product of two cyclic groups with application on regular embeddings of bipartite graph.
- Classification of various classes of regular maps
- Construction: infinite classes of regular maps that are both self-dual and self-Petrie-dual
- Asymptotic formulas for counting oriented and the number of reflexible maps
- Matching numbers of intersection graphs of bases is characterized.
- Optimal acyclic edge-colourings of cubic graphs are described.
- Progress towards 6-decompositions of snarks.

#### **PI8-Stadler**

- An explicit construction of a minimum cycle bases for the lexicographic product of graphs.
- Application of redundant non-invertible encodings in hard combinatorial optimization problems
- An efficient heuristic for constructing alternative local multiple sequence alignments from a collection of local pairwise alignments developed, tested.
- Retracts of Cartesian products of chordal graphs characterized.
- Uniqueness of prime factorization of thin hypergraphs w.r.t. strong products has been proved and factorization algorithm is given.

#### **AP1 Conder**

- Significant progress in generation and counting, of small regular polytopes, symmetric 3-valent graphs, regular maps and regular and special classes of chiral polytopes, regular Cayley maps for cyclic groups. Building several abstract polytope atlases.
- Construction of special families maps, half-arc transitive graphs, symmetric regular covers of kaleidoscopic regular maps with trinity symmetry
- Algorithms, local  $s$ -transitivity in Magma, finding apartments in coset geometries,
- Conder selected by the American and New Zealand Mathematical Societies as the first Maclaurin Lecturer, given the title of Distinguished Professor at the University of Auckland, and elected a Fellow of the American Mathematical Society

#### **AP2-Fowler**

- Elected as a Fellow of the Royal Society (FRS).
- Established the mathematical background for definition of omniconducting graphs, chemical applications, conducting properties of fullerenes
- Successful use of purely graph theoretical models in quantum mechanical approaches
- Use of symmetry and graph theory for framework rigidity in engineering structures

#### **AP3-Imrich**

- book published : Handbook of product graphs
- elected as a member of Academia Europea, section Informatics

**AP4-Klin**

- 4 new infinite families of non-Schurian association schemes on  $2p^2$  vertices,  $p$  an odd prime
- new infinite family of non-Schurian association schemes with 3 classes, which are invariant with respect to a suitable transitive action of groups  $PSL(2,q)$ ,  $q$  is a prime-power.

**AP5-Schulte**

- proved algebraic and combinatorial conditions for a polytope  $P$  that ensure action of automorphism on  $k$ -arcs of medial layer graph is transitive. Example families provide.

- b. List up to five of your CRP's most significant joint publications (i.e. involving co-authors from at least two IPs in your CRP or co-authors from other CRPs in the programme).

1. **\*Cabello S., Chimani M., Hliněný P., Computing the stretch of an embedded graph. *SIAM journal on discrete mathematics*, ISSN 0895-4801, 2014, vol. 28, no. 3, str. 1391-1401**

2. \*Biyikoglu, Turker and Leydold, Josef, Dendrimers are the unique chemical trees with maximum spectral radius. MATCH 68(2012), 851--854.

3. **\*Sergio Cabello, Jean Cardinal, Stefan Langerman, The Clique Problem in Ray Intersection Graphs, Algorithms – ESA 2012, Lecture Notes in Computer Science Volume 7501, 2012, pp 241-252**

4. \*Conder, Marston and Nedela, Roman and Siran, Jozef, Classification of regular maps of Euler characteristic  $\leq -3p$ . J. Combin. Theory Ser. B 102 (2012), 967--981. <http://dx.doi.org/10.1016/j.jctb.2011.11.003>

5. \*S.Majstorovic, D.Stevanovic „A note on graphs whose largest eigenvalues of the modularity matrix equals zero“, Electronic Journal of Linear Algebra vol 27, 256 (2014)

## B.2. Integration of the CRP in the programme (300-600 words)

1. Describe the contribution of your CRP to the EUROCORES programme. What was the place and role of the CRP in the framework of the programme? From a scientific perspective, how well integrated was your CRP in the programme? How would you describe the intensity of interaction between your CRP and other CRPs in the programme?

Our impression is that CRPs collaborate well. Networking events contributed to this the most. GReGAS CRP is established on the basis of long term EU and worldwide cooperation established around Slovenian, Austrian and Slovak graph theory cores. The coherence of the related network is based on strong personal and long term research relationships and periodic series of the conferences (every four years) with International conference of graph theory in Bled (Slovenia) GEMS workshops (Slovak Republic), SODO series (New Zealand) and other conferences filling the remaining year in the four year cycle held in different places (USA, Portugal, Mexico). Strong connections between Austrian and Slovenian groups are kept through Ljubljana-Leoben seminar every year. Establishing the scientific journal *Ars Mathematica Contemporanea* (founding editors and editors-in-chief are PL Pisanski and PI Marušič) turned to be an important strategic decision, which have even strengthened the cooperation and brought it to the next level. GReGAS project is one of the first projects linking the parts of the network working on the common project goals. In the past and still on-going there were various smaller bilateral projects running between the different groups within the project.

Members of our CRP have, through Slovak partners, a strong connection with Czech scientists and through this to the project GraDR. Thus GReGAS has relatively good cooperation established with leaders of GraDR, while connections with other two CRPs are weaker, but getting stronger especially through researchers working on crossing number and computational geometry.

In such a setting the four CRPs represent four strong groups and EUROGIGA programme is an excellent choice to enhance cooperation between the groups. Motivated by various applications in sciences and technologies, the topics addressed in EUROGIGA call have high potential of establishing links with industry and other top sciences. Beside the strong scientific team, Slovenian GReGAS team involves also an industrial partner, Abelium company, which is a form of a spin-off from the group of PL Pisanski still keeping strong cooperation, but also rapidly developing in the industrial field. We believe that (possible) applications of theory in technology represent the strong points of EUROGIGA related topics.

We hope that the cooperation between groups in CRPs will lead to new project ideas through for application of Horizon 2020 projects.

2. Describe the benefit to your CRP of being part of the EUROCORES programme (e.g. achieving critical mass of expertise, scale and scope, visibility, collaborative opportunities, ideas, etc.).

The main benefits of the EUROCORES programme is additional support for networking events which is an interesting concept providing enhancement mechanism for inter-project cooperation. CRPs itself contribute to better possibilities for work within the CRPs team. We can notice that exchange of young researchers (PhD students, post docs) and visits have increased.

Networking events provide additional conferences and workshops “forcing” together different groups possibly providing “sparks” for new cooperation. So we absolutely support networking mechanisms and hope similar funds, especially for the biggest joint events could be provided in future.



### B.3. Cross-CRP networking, training and dissemination (max. 750 words)

1. Which networking/training/dissemination activities did you or your CRP members participate in? Indicate how many team members participated in each activity.

Kick-off meeting, Paris:

- 2 GReGAS members attended the event

EuroGIGA Minisymposia at CSASC, 25-28 September 2011. Two minisymposia organized:

- **"Algebraic and topological graph theory"**, Organizers: Roman Nedela (Banska Bystrica), Tomasz Pisanski (Ljubljana) - Organized by our CRP
- **"Combinatorics and Graph Theory"**, Organizers: Michael Drmota (Vienna), Jan Kratochvil (Prague), Marc Noy (Barcelona), Oriol Serra (Barcelona)
  - 9 GReGAS members attended the event

SODO 2012 - Symmetries of Discrete Objects Conference and MAGMA Workshop, Queenstown, New Zealand, 13-17 February 2012:

- 16 GReGAS members attended the event

EuroGIGA Session in Assisi, on March 22, 2012, Assisi, Italy

- 1 GReGAS members attended the event

Eurogiga Midterm Conference, July 9-13, 2012, Prague, Czech Republic

- 13 GReGAS members attended the event

Computers in Scientific Discovery 6, August 21-25, Portorož, Slovenia

- 25 GReGAS members attended the event

CSASC Koper, 9-13 June, Koper, Slovenia

- 24 GReGAS members attended the event
- 3 out of 9 scientific minisymposia co-organised by GReGAS members

EuroGIGA Final Conference in Berlin, February 17-21, 2014

- 11 GReGAS members attended the event

EuroGIGA session at the GEMS workshop (Graph Embeddings and Maps on Surfaces), 14-19 July 2013, Smolenice, Slovakia

- 11 GReGAS members attended the event

Ljubljana-Leoben Graph Theory Seminar, 3-5 September, 2014, Koper, Slovenia

- 15 GReGAS members attended the event

2. **Networking activities.** Describe *the most important networking activity* for your CRP (in terms of impact, outcome, creation of synergy and cooperation within or outside the programme).

We believe that the most important networking activity was Conference of the Catalan, Slovenian, Austrian, Slovak and Czech mathematical societies, 9-13 June, Koper

- Traditional conference organized every two years
- 24 GReGAS members attended the event and members of all other EUROGIGA projects attended the conference as well
- <http://csasc2013.upr.si/>
- 9 scientific, 1 educational and 1 EUROGIGA minisymposia

- 108+ participants

3. **Training activities.** Describe *the most useful training activity* to date (workshop, course, school, etc.) undertaken by senior or junior researchers of your CRP.

- Within SODO 2012 a Magma workshop was organized.
- Two-week Summer school, "Topics in Algebraic graph theory" (Banska Bystrica, Slovakia).
- PhD Summer School in Discrete Mathematics and Symmetries of Graphs and Networks III (Rogla, Slovenia)
- PhD Summer School in Discrete Mathematics, Rogla, Slovenia / 16 - 21 June 2013
- 2014 PhD Summer School in Discrete Mathematics, Rogla, Slovenia / 29 June - 5 July 2014

4. **Dissemination activities.** Describe the *most valuable dissemination activity (or activities)* your team undertook, with respect to (i) the scientific community and (ii) the wider public. Describe the outcome and impact of these activities in terms of promoting your field of research and the EUROCORES programme.

Organisation or co-organisation of events:

- 7th Slovenian International Conference on Graph Theory, Bled, Slovenia, 19 – 25 June 2011
- Meeting "Mathematics and Art", Ljubljana, Slovenija, junij, 2011
- Annual meeting of International academy for mathematical chemistry, Bled, Slovenija, junij 2011
- CSASC 2011, Krems Austria, T. Pisanski, R. Nedela chairing "Algebraic and topological graph theory" session. Also organization of EUROGIGA session.
- SODO 2012, Symmetries of Discrete Objects, Conference and MAGMA Workshop, Queenstown, New Zealand, 13-17 February 2012
- Computers in Scientific Discovery (CSD) conference: CSD6 August 2012, Portorož, SI. This meeting had participants from chemistry, mathematics & computer science, with a strong representation from GREGAS researchers, and invited speakers included Nobel Laureate Sir Harold Kroto, whose seminal work on fullerenes is central to our theme of using graph theoretical ideas in chemical applications.
- Joint Mathematical Conference CSASC 2013, 9.-13. 6. 2013 in Koper, Slovenia.
- Graph Embeddings and Maps on Surfaces, GEMS 2014, Smolenice, Slovakia, 14.-19. 7. 2013 (organizers: Nedela, Škoviera, member of program committee: Širan, organization: Mačaj, Karabaš, Kotrbčik; Širan, Škoviera are the editors of the special issue of Ars Mathematica Contemporanea)
- 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics, Algorithms and Applications, organized in Košice, 7-13.7. 2013 (Nedela, Škoviera – members of program committee; Škoviera – editor of special issue of Discrete Mathematics)
- EuroComb 2013, Pisa, Italy, 9.-13. 9. 2013, program committee member: Škoviera
- 7th Cracow Conference on Graph Theory "Rytro '14" , partnered through the Standard Grant of the Visegrad Fund: Škoviera
- 6th International Workshop on Optimal Network Topologies IWONT 2014, 30. 6. -4. 7. 2014, Bratislava, Slovakia, main organizers: Jajcay and Širan
- Working retreat of the research team, 10.12.-14.12. 2014, Mosonmagyaróvár, Hungary. Organizer: Škoviera
- Adriatic Conference on Graph Theory and Complexity, Split, Croatia, 25-27 April 2014.
- ATCAGC 2013: Algebraic, Topological and Complexity Aspects of Graph Covers, Bovec, Slovenia / 28 January - 1 February 2013
- DM|=60: |DM|=60 International Conference on Graph Theory and Combinatorics, dedicated to Prof. Dragan Marušič's 60th Birthday, Koper, Slovenia / 1 - 3 May 2013
- Joint Workshop of Math Departments UP IAM and UP FAMNIT, Rogla, Slovenia / 17 - 19 May 2013
- Conference on Geometry: Theory and Applications, Ljubljana, Slovenia / 24 - 28 June 2013
- 2nd Annual Mississippi Discrete Mathematics Workshop, Starkville, USA / 2 November 2013

- SYGN IV: Symmetries of Graphs and Networks IV, Rogla, Slovenia / 29 June - 5 July 2014

**Associate partners**

- Royal Society Workshop: Symmetry, Rigidity & Periodicity in Natural & Engineered Structures, Chicheley Hall, Feb. 2012 (P. W. Fowler, initiator and co-organizer)
- Aromaticity, International Conference on Physical Organic Chemistry (ICPOC21), Durham Sept, 2012 (P. W. Fowler, co-organizer)

5. List the cross-CRP activities your CRP organised or co-organised.

EuroGIGA Minisymposia at CSASC, 25-28 September 2011. GReGAS PL Pisanski and PI Nedela organized one of two EuroGIGA minisymposia:

- **"Algebraic and topological graph theory"**, Organizers: Roman Nedela (Banska Bystrica), Tomasz Pisanski (Ljubljana) - Organized by our CRP
- **"Combinatorics and Graph Theory"**, Organizers: Michael Drmota (Vienna), Jan Kratochvil (Prague), Marc Noy (Barcelona), Oriol Serra (Barcelona)
  - 43 participants.
  - Organizers: GReGAS + GraDR
  - web: <http://www.dmg.tuwien.ac.at/OMG/OMG-Tagung/>

**SODO 2012 - Symmetries of Discrete Objects Conference and MAGMA Workshop, Queenstown, New Zealand, 13-17 February 2012:**

- 67 Participants.
- Organizers: GReGAS + GraDR
- web: <http://www.math.auckland.ac.nz/~conder/SODO-2012/>

**Computers in Scientific Discovery 6, August 21-25, Portorož, Slovenia**

- Scientific committee: Tomaž Pisanski (chair), Patrick Fowler, Klavdija Kutnar.
- Organizing committee: Klavdija Kutnar (chair), Boštjan Frelih, Ademir Hujdurović, Alen
- Organizers: GReGAS + ComPose

**CSASC Koper, 9-13 June, Koper, Slovenia**

- T. Pisanski, J. Kratochvil, R. Nedela – members of national scientific committees
- Organizing committee: K. Kutnar, A. Orbanic, T. Pisanski, J. Prezelj
- 3 out of 9 minisymposia coorganized by GReGAS members
- Eurogiga minisymposium held
- Organized by all EUROGIGA projects

**GEMS workshop (Graph Embeddings and Maps on Surfaces), 14-19 July 2013, Smolenice, Slovakia**

- main organizers: Nedela, Škoviera, in cooperation with GraDR
- GReGAS members of program committee: Širan,
- organization: Mačaj, Karabaš, Kotrbčik

**Ljubljana-Leoben Graph Theory Seminar, 3-5 September, 2014, Koper, Slovenia**

- GReGAS members of scientific committee: Imrich W., Klavžar S., Kutnar K., Pisanski T.
- GReGAS members of organizing committee: Brešar B., Jakovac M., Kelenc A., Milanič M.

## B.4. Publications, dissemination and outreach

**Important:** In your lists, include only those publications which resulted to a significant extent from work undertaken in the framework of the CRP or from collaboration with other CRPs. Note that all such publications should bear an acknowledgement of the EuroGIGA programme.

**In addition:**

- List *all* authors.
- Identify with an asterisk (\*) publications which acknowledge the EUROCORES programme.
- Underline publications/presentations involving co-authors from at least two IPs within your CRP.
- **Mark in bold publications/presentations involving co-authors from other CRPs in the programme.**

### Publications

- Articles

*Peer-reviewed articles in journals (published, in press or submitted)*

**PL Pisanski**

Bauer, Andrej, On the failure of fixed-point theorems for chain-complete. Theoret. Comput. Sci. 430 (2012), 43--50. <http://dx.doi.org/10.1016/j.tcs.2011.12.005>

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- net.Plexor - will be collected from contributions (<http://www.abelium.eu/development/net.plexor>)

- GReGAS Atlas - Encyclopedia of Graphs (<http://atlas.gregas.eu/>)
- Batagelj. V., A. Mrvar, A. WoS2Pajek 1.0 (October 2011). A program for transforming WoS data into corresponding Pajek networks. Python source <http://pajek.imfm.si/lib/exe/fetch.php?media=dl:wos2pajek10.zip>
- V. Batagelj. Preprint 0.3 (Jun 2012). A program for transforming citation networks with some small strong components into corresponding acyclic network. Python source: <http://pajek.imfm.si/lib/exe/fetch.php?media=dl:preprint.py>
- V. Batagelj, lanus – Python tool for dynamic network analysis and visualization (<http://pajek.imfm.si>)
- V. Batagelj, TQ – Python tool for temporal quantities (<http://pajek.imfm.si>)

## Presentations in scientific meetings

- Oral presentations (indicate invited / keynote talks)

7th Slovenian International Conference on Graph Theory, Bled, Slovenia, June 2011 (majority of project members, invited speakers: Škoviera, Imrich, Schulte)

T. Pisanski. Meeting "Mathematics and Art", Ljubljana, Slovenija, June 2011

T. Pisanski. Workshop on Symmetry in Graphs, Maps, and Polytopes, Toronto, Canada, October 2011 (invited speaker)

T. Pisanski. The 35th Australasian Conference on Combinatorial Mathematics & Combinatorial Computing, Monash University, Melbourne, Australia, December 2011

Batagelj Vladimir, Cerinšek Monika, Horvat Boris: Network analysis of Zentralblatt MATH data. 7th Slovenian International Conference on Graph Theory, Jun 2011, Bled, Slovenia.

Bodlaj Jernej, Batagelj Vladimir, Orbančić Alen: OpenGL® Graphical User Interface for net.Plexor - Interactive Large Network Analysis Library. 7th Slovenian International Conference on Graph Theory, Jun 2011, Bled, Slovenia.

Batagelj Vladimir, Cerinšek Monika, Horvat Boris, Pisanski Tomaž: Exploring the structure of mathematical publications, CSASC 2011, September 2011, Krems, Austria.

Batagelj Vladimir, Cerinšek Monika, Horvat Boris, Pisanski Tomaž: The structure of mathematics from Zentralblatt MATH data. 16th Young Statisticians Meeting, October 2011, Rijeka, Croatia.

Batagelj Vladimir, Cerinšek Monika, Horvat Boris, Pisanski Tomaž: The structure of mathematics from the Zentralblatt MATH data base. Sunbelt XXXII, March 2012, Redondo Beach, CA, USA.

Breznik Kristijan, Batagelj Vladimir: Network analysis of tennis games in the Open Era. Sunbelt XXXII, March 2012, Redondo Beach, CA, USA.

Sandi Klavžar: Fibonacci cubes, generalized Fibonacci cubes, and bad words, invited plenary talk at Combinatorics 2012, Perugia, Italy, September 2012 (invited talk).

Sandi Klavžar: Generalized Fibonacci cubes and three related problems on binary words, invited plenary talk at The 21st Workshop '3in1', Krakow, Poland, November 2012 (invited talk).

Aleksander Vesel: Linear recognition and embedding of Fibonacci cubes, talk at Combinatorics 2012, Perugia, Italy, September 2012 (invited talk).

Math Chem Comp, Dubrovnik (13.6.-18.6.2011) // Snjezana Majstorovic, Antoaneta Klobucar: K-domination on hexagonal chain cacti (talk)

EuroGiga Midterm Conference, July 2012, Prague, Czech Republic // Snjezana Majstorovic: Domination on m-ary chain cacti (talk)

8th Meeting of the International Academy of Mathematical Chemistry, June 2012, Verona, Italy // Snjezana Majstorovic: Bounds and relations involving betweenness centrality in some families of graphs (talk)

MATH/CHEM/COMP 2011 (Dubrovnik) // Sedlar Jelena, Vukičević Damir, Rajtmajer Sarah Michele, "On ordering alkanes by modified Zagreb indices" //

7th Slovenian International Conference on Graph Theory (Bled, 2011) //D. Vukičević, "Community detection in complex networks"

Dragan Marušič, On two open problems in vertex-transitive graphs, ``Beijing International Workshop on Group Actions on Combinatorial Structures'', August 21 - 27, 2011, Beijing, China. (INVITED TALK).

Klavdija Kutnar, Classification of cubic symmetric polycirculants, ``Beijing International Workshop on Group Actions on Combinatorial Structures'', August 21 - 27, 2011, Beijing, China. (INVITED TALK).

Edward Dobson, Which Johnson graphs and folded Johnson graphs are Cayley graphs, ``Beijing International Workshop on Group Actions on Combinatorial Structures'', August 21 - 27, 2011, Beijing, China. (INVITED TALK).

Dragan Marušič, Searching for snarks amongst Cayley graphs, ``CID 2011 Colourings, Independence and Domination 14th WORKSHOP ON GRAPH THEORY'' September 18 - 23, 2011, Szklarska Poreba, Poland.

Klavdija Kutnar, Cubic Cayley graphs and snarks, ``Workshop on Symmetry in Graphs, Maps, and Polytopes'', October 24-27, 2011, the Fields Institute, Toronto, Canada (INVITED TALK).

Dragan Marušič, Half-arc-transitive graphs - possible research directions, ``Workshop on Symmetry in Graphs, Maps, and Polytopes'', October 24-27, 2011, the Fields Institute, Toronto, Canada.

Aleksander Malnič, On the Split Structure of Lifted Groups, ``Workshop on Symmetry in Graphs, Maps, and Polytopes'', October 24-27, 2011, the Fields Institute, Toronto, Canada .

Klavdija Kutnar, Quasi  $m$ -Cayley strongly regular graphs, ``SODO2012 - Symmetries of Discrete Objects'', February 13 - 17, 2012, Queenstown, New Zealand.

Aleksander Malnič, On the split structure of lifted groups, I, ``SODO2012 - Symmetries of Discrete Objects'' February 13 - 17, 2012, Queenstown, New Zealand.

Klavdija Kutnar, Cubic Cayley graphs and snarks, International Conference on Cycles in Graphs, Nashville, USA, May 30 - June 2, 2012 (Invited Speaker).

Dragan Marušič, Hamiltonicity of cubic Cayley graphs, International Conference on Cycles in Graphs, Nashville, USA, May 30 - June 2, 2012 (Invited Speaker).

Istvan Kovacs, Characterization of cyclic Schur groups, AAA84 84th Workshop on General Algebra, Dresden, Germany, June 8 - 10, 2012

Klavdija Kutnar, Distance-transitive graphs admit semiregular automorphisms, MDA 2012 - Mathematics of Distances and Applications, Varna, Bulgaria, July 2 - July 5, 2012 (Invited Speaker).

Dragan Marušič, An infinite family of half-arc-transitive graphs with universal reachability relation, MDA 2012 - Mathematics of Distances and Applications, Varna, Bulgaria, July 2 - July 5, 2012 (Invited Speaker).

Aleksander Malnič, On the split structure of lifted groups, I, MDA 2012 - Mathematics of Distances and Applications, Varna, Bulgaria, July 2 - July 5, 2012 (Invited Speaker).

Martin Milanič, Equistable graphs: conjectures, results, and connections with Boolean functions, 25th European

Conference on Operational Research, Vilnius (Lithuania), July 8-11, 2012.

Martin Milanič, Uniqueness of independence polynomials in monogenic graph classes, International Colloquium on Graphs and Optimization 2012, Leukerbad, Switzerland, August 13-17, 2012.

7th Slovenian International Conference on Graph Theory 19-25 June 2011, Bled, Slovenia

- Martin Skoviera: Snarks - Recent development (keynote lecture)
- Ján Karabáš: Classification of Edge-transitive Maps Michal Kotrbáčik: High-genus Embeddings
- Martin Macaj: Nonorientable Regular Maps Over Linear Fractional Groups
- Roman Nedela: Asymptotic Enumeration of Reversible Maps Regardless of Genus

23rd British Combinatorial Conference University of Exeter, 4-8 July, 2011.

- Jozef Širáň, Nonorientable regular maps of any given type over linear fractional groups

IWONT 2011 International Workshop on Optimal Network Topologies Brussels, Belgium, July 11 - 15, 2011

- Jana Siagiova: Cayley graphs in the degree-diameter problem (keynote lecture)
- Martin Knor: On 3-arc graphs
- Martin Macaj: Search for properties of the missing Moore graph
- Maria Zdimalova: A family of large vertex-transitive graphs of diameter 2

Group Actions on Combinatorial Structures Beijing, August 21-27, 2011

- Martin Skoviera Regular maps with nilpotent automorphism groups
- Ján Karabáš: Discrete groups of automorphisms of orientable surfaces
- Roman Nedela: Discrete groups of automorphisms of surfaces with given genus
- Jozef Siran: External symmetries of regular maps

Workshop on Symmetry in Graphs, Maps, and Polytopes Fields Institute Toronto, October 24-27, 2011

- Martin Skoviera: Regular maps with nilpotent automorphism groups
- Jan Karabas: Classification of edge-transitive maps
- Martin Macaj: Nonorientable Regular Maps and Residual Finiteness of Triangle Groups
- Roman Nedela: Vertex Transitive and Edge Transitive Polytopes and 2-Dimensional Orbifolds
- Jozef Siran: External Symmetries of Regular and Orientably Regular Maps

AMS Special Session on Topological Graph Theory, Structure and Symmetry, Boston, January 4-7, 2012

- Martin Skoviera: Locally Maximal Embeddings of Graphs in Orientable Surfaces (invited lecture)
- Roman Nedela: A recent progress in map enumerations (invited lecture)
- Roman Nedela: Vertex transitive polyhedral maps and actions of discrete groups on surfaces (invited lecture)

ATCAGC 2012 Workshop on Algebraic, Topological and Complexity Aspects of Graph Covers 26th - 31st January 2012, Eugene, Oregon

- Roman Nedela: Flows and graph coverings

SODO 2012 Symmetries of Discrete Objects Conference and MAGMA Workshop Queenstown, New Zealand, 12-17 February 2012

- Jan Karabas: Discrete group actions on orientable surfaces
- Martin Macaj: On the Wilson operators
- Jozef Siran: Imprimitivity of locally finite, 1-ended, planar graphs

Eurogiga Midterm Conference Prague, July 9-13, 2012

- Martin Skoviera: Regular maps with nilpotent automorphism groups (invited lecture)

IWONT 2012 The 5th International Workshop on Optimal Network Topologies July 27 – 29, 2012 Institut Teknologi Bandung, Indonesia

- Jozef Siran: A survey of algebraic methods in the degree-diameter problem (keynote lecture)
- Martin Knor: Graphs with given degree and diameter on the smallest number of vertices

- Jana Siagiova: Quotients of large vertex-transitive and Cayley graphs of given degree and diameter

ACCOTA 2012 International Workshop Combinatorial and Computational Aspects of Optimization, Topology and Algebra December 3 to 7, 2012. Huatulco, Oaxaca, México

- Martin Skoviera: Odd decompositions of regular eulerian graphs of odd orders
- Jozef Siran: Algebraic methods in the degree-diameter problem

T. Pisanski, Abstract polygonal complexes (with an application to synthetic biology), GEMS 13, Smolenice, Slovakia, July 2013 (invited speaker)

T. Pisanski, An interplay between topological graph theory and synthetic biology, Second Joint International Meeting of the Israel Mathematical Union and the American Mathematical Society, Tel Aviv, Israel, June 2014

S. Cabello, The clique problem in ray intersection graphs, Congress of the Spanish Mathematical Society, Santiago de Compostela, Spain, Januar 2013.

S. Cabello, Computing the stretch of an embedded graph, XV Spanish Meeting on Computational Geometry, Sevilla, Spain, June 2013.

S. Cabello, Stackelberg shortest path tree game, revisited, 12th International Symposium on Operational Research in Slovenia, Dolenjske Toplice, September 2013.

S. Cabello, Parameterized complexity of 1-planarity, BIRS Workshop: Geometric and Topological Graph Theory, Banff, Canada, september 2013.

S. Cabello, Parameterized complexity of 1-planarity, Dagstuhl seminar: Algorithms for Optimization Problems in Planar Graphs, Dagstuhl, Germany, October 2013.

D. Marušič, Semiregular subgroups of transitive permutation groups, 22nd Workshop '3in1', Kroczyce, Poland, November 2013 (invited speaker).

D. Marušič, On prime-valent symmetric bicirculants and Cayley snarks, 1st International Conference "Geometric science of information", GSI 2013, Pariz, France, Avgust 2013.

P. Potočnik, On covers of doubled cycles, 5th International Workshop on Algebraic, Topological and Complexity Aspects of Graph Covers, Bovec, Slovenia, January 2013.

P. Potočnik, How many symmetries can a symmetric graph have?, 37th Australian Conference on Combinatorial Mathematics and Combinatorial Computing, Perth, Australia, December 2013.

V. Batagelj, Big data: Networks from data bases, Undicesima conferenza nazionale di statistica, Rome, Italy, February 2013 (invited speaker)

V. Batagelj, Analysis of Large Bibliographic Networks, 4th International Workshop on Social Network Analysis: Networks in Space and Time (ARS'13), Rome, Italy, June 2013 (invited speaker).

V. Batagelj, Introduction to network analysis, Short Phd Course, The Economics of Innovative Change; Dept. of Economics of the Friedrich Schiller University and the Max Planck Institute of Economics, Jena, Germany, July 2013.

V. Batagelj, Introduction in network analysis, dvotedenski tečaj na 8th ECPR (European Consortium for Political Research) Summer School in Methods and Techniques, Fakulteta za družbene vede, Ljubljana, Slovenia, July/August 2013.

V. Batagelj, Analysis of citation networks, Daegu International Social Network Conference (DISC'13), Daegu, South Korea, December 2013 (invited speaker).

V. Batagelj, Symbolic clustering of users and antennae, 3rd conference on the Analysis of Mobile Phone Datasets, NetMob, Cambridge (Massachusetts), USA, May 2013.

V. Batagelj, Visualization of traffic, 3rd conference on the Analysis of Mobile Phone Datasets, NetMob, Cambridge (Massachusetts), USA, May 2013.

V. Batagelj, Workshop: Analysis of large networks with Pajek, XXXIII International Sunbelt Social Network Conference, Hamburg, Germany, May 2013.

V. Batagelj, Approaches to Analysis of Citation Networks, XXXIII International Sunbelt Social Network Conference, Hamburg, Nemčija, maj 2013.

V. Batagelj, Analysis of Bibliographic Networks on "Social Networks", XXXIII International Sunbelt Social Network Conference, Hamburg, Germany, May 2013.

V. Batagelj, Pajek tutorial, 4th International Workshop on Social Network Analysis: Networks in Space and Time (ARS'13), Rome, Italy, June 2013.

V. Batagelj, Analysis of Large Bibliographic Networks: Collaboration Networks, INSNA'13, Xi'an, China, July 2013.

V. Batagelj, Clustering of US counties based on their demographic structures, Conference of the International Federation of Classification Societies, IFCS-2013, Tilburg, Netherlands, July 2013.

V. Batagelj, On collecting the sport networks data from the web, 5th conference of the European Survey Research Association, Ljubljana, Slovenia, July 2013.

V. Batagelj, Analysis of bibliometric networks, 27th Leoben-Ljubljana Graph Theory seminar, Graz, Austria, September 2013.

A. Bauer, An effect system for algebraic effects and handlers, 5th Conference on Algebra and Coalgebra in Computer Science, Warsaw, Poland, September 2013 (invited lecture).

A. Bauer, Geometric realization of  $r$ -Tamari lattices, CSASC 2013, Koper, Slovenia, June 2013.

A. Bauer, Number of standard strong marked tableaux, 25th International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC 2013), Paris, France, June 2013.

A. Bauer, Results and conjectures on the number of standard strong marked tableaux, European Conference on Combinatorics, Graph Theory and Applications - Eurocomb 2013, Pisa, Italy, September 2013.

T. Pisanski, TheCover, 5th International Workshop on Algebraic, Topological and Complexity Aspects of Graph Covers, Bovec, January/February 2013 (invited lecture)

T. Biyikoglu, "Discrete and continuous models in the theory of networks" Cooperation Group Meeting, Center for Interdisciplinary Research (ZIF), Bielefeld, Germany, May 2013 (invited speaker).

7th Slovenian International Conference on Graph Theory, Bled, Slovenia, June 19-25, 2011

- Peter F. Stadler: Orthology Relations and the Reconciliation of Gene and Species Trees.
- Lydia Ostermeier: Square Property and Equitable Partitions.

Eurogiga Midterm Conference, Prague, Czech Republic, July 9-13, 2012

- Lydia Ostermeier: Square Property and Equitable Partitions.

Indo-Slovenia Conference on Graph Theory and Applications, Thiruvananthapuram, India, February 22-24, 2013

- Peter F. Stadler: Graph grammars and directed hypergraphs: Discrete models of chemistry. (Plenary talk)
- Matjaž Kovše: Topological representations of partial cubes. (Invited talk)
- Lydia Ostermeier: Grid Property and Product-like Hypergraphs.

First International Conference in Code Biology, Paris, France, May, 20-24, 2014

Peter F. Stadler: Graph grammars and the Analysis of Large (Bio)chemical Networks.



K. Hu: Classification and enumeration of cyclic regular coverings of the platonic maps, Algebraic, Topological and Complexity Aspects of Graph Covers, Bovec, Slovenia, 28. 1.-1. 2. 2013 (invited speaker).

R. Nedela: Recent progress in map enumeration, Geometry Days in Novosibirsk, Novosibirsk· öt·tna univerzita, Novosibirsk, Russia, 23.-27. 8. 2013 (invited speaker).

R. Nedela: Half-arc-transitive actions with cyclic stabilizers and their geometric visualisation, International Conference on Graph Theory and Combinatorics DM60, Koper, Slovenia, 1.-3. 5. 2013 (invited speaker).

R. Nedela: Recent development in classification of regular embeddings of graphs, 2nd International Conference on Group Actions and Transitive Graphs, Kunming, China, 4.-9. 9. 2013 (invited speaker).

J. Širan: How symmetric can maps on surfaces be? 24th British Combinatorial Conference BCC 2013, Royal Holloway, University of London, UK, 30. 6. - 5. 7. 2013 (invited speaker).

J. Širan: Regular maps on a given surface, TGT25 - The 25th International Workshop in Topological Graph Theory, Yokohama National University, Japan, 18.-22. 11. 2013 (invited speaker).

M. Škoviera: Cycle bases, matchings, and the maximim genus of graphs, Indo-Slovenia Conference on Graph Theory & Applications, Thiruvananthapuram, India, 22.-24. 2. 2013 (invited speaker).

M. Škoviera: Hamilton cycles in truncated triangulations, TGT25 - The 25th International Workshop in Topological Graph Theory, Yokohama National University, Japan, 18.-22. 11. 2013 (invited speaker).

B. Candrakova: The circular chromatic index of line graphs of cubic snarks, 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics Algorithms and Applications, Koöice, 11.07.2013.

B. Candrakova: The circular chromatic index of k-regular graphs, EuroComb 2013, Pisa, Taliansko, 9.-13. 9. 2013.

K. Hu: Group extensions and coverings of maps, Graph Embeddings and Maps on Surfaces, GEMS 2013, Smolenice, 14.-19. 7. 2013.

K. Hu: Almost totally branched coverings over the platonic maps, 2nd International Conference on Group Actions and Transitive Graphs, Kunming, China, 4.-9. 9. 2013.

J. Karabaš: Discrete group actions on orientable surfaces, Algebraic, Topological and Complexity Aspects of Graph Covers, Bovec, Slovenia, 28. 1.-1. 2. 2013.

J. Karabaš: Discrete Group Actions on Orientable Surfaces, Geometry Days in Novosibirsk, Novosibirsk· öt·tna univerzita, Novosibirsk, Russia, 23.-27. 8. 2013.

M. Kotrbčik: Locally maximal embeddings, Geometric and Topological Graph Theory, Bristol, UK, 15.ñ19. 4. 2013.

M. Kotrbčik: Genus of amalgamations of complete and complete bipartite graphs, 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics Algorithms and Applications, Koöice, 11.07.2013.

M. Kotrbik: Locally maximal embeddings, Graph Embeddings and Maps on Surfaces, GEMS 2013, Smolenice, 14.-19. 7. 2013.

M. Kotrbčik: Locally maximal of graphs in orientable surfaces, EuroComb 2013, Pisa, Taliansko, 9.-13. 9. 2013.

M. Knor: Fullerene-like maps on hyperbolic surfaces, Geometric and Topological Graph Theory, Bristol, UK, 15.ñ19. 4. 2013.

M. Knor: Efficient domination in cubic vertex-transitive graphs on  $2^n$  vertices, PhD Summer School in Discrete Mathematics, Rogla, Slovenia, 16.-21. 6. 2013.

M. Knor: Efficient domination in 3-valent vertex-transitive graphs, 7th Czech-Slovak International Symposium on

Graph Theory, Combinatorics Algorithms and Applications, Košice, 7.-13. 7. 2013.

M. Knor: Graphical models of hyperbolic fullerenes, Graph Embeddings and Maps on Surfaces, Graph Embeddings and Maps on Surfaces, GEMS 2013, Smolenice, 14.-19. 7. 2013.

M. Knor: Deterministic models of self-similar networks, Cycles and Colourings, Nový Smokovec, 8.-13. 9. 2013.

M. Knor: Deterministic models of self-similar complex networks, 3in1, Kroczyce, 28.-30. 11. 2013.

R. Lukotka: Avoiding 7-circuits in 2-factors of cubic graphs, 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics Algorithms and Applications, Košice, 7.-13. 7. 2013.

R. Lukotka: Degenerate induced subgraphs of planar graphs, EuroComb 2013, Pisa, Italy, 9.-13. 9. 2013.

M. Mačaj: Vertex-transitive graphs of given degree and diameter, Joint Mathematical Conference CSASC 2013, Koper, Slovenia, 9.-13. 6. 2013.

E. Mačajova: On even cycle decompositions of 4-regular line graphs, 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics Algorithms and Applications, Košice, 7.-13. 7. 2013.

E. Mačajova: Snarks with large oddness and small number of vertices, Eurocomb 2013, Pisa, 9.-13. 9. 2013.

J. Mazak: Circumference of cubic graphs, 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics Algorithms and Applications, Košice, 7.-13. 7. 2013.

J. Mazak: Non-trivial snarks with given circular chromatic index, Eurocomb 2013, Pisa, 9.-13. 9. 2013.

R. Nedela: Branched covers over Platonic maps, Joint Mathematical Conference CSASC 2013, Koper, Slovenia, 9.-13. 6. 2013.

R. Nedela: Archimedean operations on maps, 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics Algorithms and Applications, Košice, 7.-13. 7. 2013.

R. Nedela: Hamilton cycles in truncated triangulations, 3in1, Kroczyce, 28.-30. 11. 2013.

E. Rollova: Nowhere-zero flows on products of graphs, 7th Workshop on the Matthews-Sumner Conjecture and Related Problems, Domažlice, Czech republic, 24.-29. 3. 2013.

E. Rollova: Signed homomorphisms of planar signed graphs to signed projective cubes, 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics, Algorithms and Applications, Košice, 7.-13. 7. 2013.

E. Rollova: Signed homomorphisms of planar signed graphs to signed projective cubes, EuroComb 2013, Pisa, Italy, 9.-13. 9. 2013.

J. Šiagova: Lifting constructions of large vertex-transitive and Cayley graphs of given degree and diameter, 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics, Algorithms and Applications, Košice, 7.-13. 7. 2013.

J. Šíran: Large vertex-transitive graphs of diameter two and given degree from finite projective planes, 7th Czech-Slovak International Symposium on Graph Theory, Combinatorics, Algorithms and Applications, Košice, 7.-13. 7. 2013.

M. Škoviera: Cycle bases, matchings, and the maximum genus of graphs, Geometric and Topological Graph Theory, Bristol, UK, 15.-19. 4. 2013.

R. Nedela, Graph coverings and harmonic functions of graphs, 2014 Joint Math. Meetings of AMS and MAA, AMS Special Session on Topological Graph Theory: Structure and Symmetry Baltimore, 15.-18. 1. 2014. (invited talk)

M. Škoviera, Bounding the order of a regular map with nilpotent automorphism group, 2014 Joint Math.



Meetings of AMS and MAA, AMS Special Session on Topological Graph Theory: Structure and Symmetry  
Baltimore, 15.-18. 1. 2014. (invited talk)

Snježana Majstorović, Euro Mini Conference XXVIII on Variable Neighborhood Search, 4-7.10.2012, Herceg Novi, Montenegro. "A Variable Neighborhood Search Algorithm for Multiobjective Optimization in Graph Theory" (joint work with Gilles Caporossi)

Snježana Majstorović, Midsummer Combinatorial Workshop XIX, srpanj 2013, Prague, "Spectrum of modularity matrix of graphs"

Tanja Vojković, 11. EuroGIGA Final Conference, 17-21.1.2014, Berlin, "Agents and distributed keys"

Jelena Sedlar, 11. EuroGIGA Final Conference, 17-21.1.2014, Berlin, "Remoteness, proximity and few other distance invariants in graphs"

Damir Vukičević, 11. EuroGIGA Final Conference, 17-21.1.2014, Berlin, "Distributed keys and agents"

Tanja Vojković, 12. CompleNet, Bologna, 12-14.3. 2014., "Agents and key distribution" (joint work with Damir Vukičević and Vinko Zlatić)

S.Majstorović, 13. Adriatic Conference on Graph Theory and Complexity, Split, 25-27.4.2014., "Bounds and relations on the betweenness centrality of graphs"

D.Vukičević, 13. Adriatic Conference on Graph Theory and Complexity, Split, 25-27.4.2014., "Protecting Secrets by Distributed Keys"

T.Vojković, 13. Adriatic Conference on Graph Theory and Complexity, Split, 25-27.4.2014., "Agents and Missing Persons in Networks with Distributed Keys"

A.Klobučar, Conference on Operation Reseach KOI 2014, Osijek, Croatia, September 24-26,2014, "Roman domination number on cardinal product of paths and cycles"

KLAVŽAR, Sandi, Wiener index in weighted graphs. V: 15th Workshop on Graph Theory: Colourings, Independence and Domination, Szklarska Poręba 2013, September 15-20.

KLAVŽAR, Sandi. Two applicable network families: Fibonacci cubes and Sierpiński graphs. V: 12th International Symposium on Operational Research in Slovenia Dolenjske Toplice, Slovenia, September 25-27, 2013 (invited talk).

KLAVŽAR, Sandi. Two theorems on distances in graphs isometrically embeddable into Cartesian product graphs. V: EuroGIGA Final Conference, Freie Universität Berlin, February 17-21, 2014.

KLAVŽAR, Sandi. Some new results and approaches on the Szeged index and the Wiener index of graphs. V: 10th Meeting of the International Academy of Mathematical Chemistry, Split, June 7-10, 2014.

KLAVŽAR, Sandi. Recent developments on the cut method. V: 5th KIAS Combinatorics Workshop, Korea Institute for Advanced Study, Seoul, Korea, September 26 - 27, 2014. *The 5th KIAS Combinatorial Workshop*. Seoul: KIAS, 2014 (invited talk).

#### **Associate partners**

Berman, L. W. Fields Institute Thematic Program on Discrete Geometry and Applications: Workshop on Symmetry in Graphs, Maps and Polytopes, Oct 24 -- 27, 2011, <http://www.fields.utoronto.ca/programs/scientific/11-12/discretegeom/talks/october.html>

M. Conder. 'The smallest regular polytopes of each rank'. Presented at 35th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing, Melbourne, Australia, December 2011

M. Conder. 'A new approach to finding covers of arc-transitive graphs'. Presented at Workshop on Algebraic,

Topological and Complexity Aspects of Graph Covers (ATCAGC 2012), Eugene, Oregon, USA, January 2012.

M. Conder. 'Finitely-presented groups in MAGMA'. Presented at Conference on Symmetries of Discrete Objects (SODO 2012), Queenstown, New Zealand, February 2012.

M. Conder. 'The orders of symmetric graphs'. Presented at SIAM Conference on Discrete Mathematics, Halifax, Nova Scotia, Canada, June 2012.

M. Conder. 'The intersection condition for regular polytopes'. Presented at Workshop on Abstract Polytopes (WAP 2012), Cuernavaca, Mexico, July 2012.

M. Conder. 'Graph Symmetries'. Presented at 36th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing (36ACCMCC), Sydney, Australia, December 2012.

P. W. Fowler. Ruđer Bošković Institute, Zagreb, 3 July 2012. Invited lecture in series: Eminentni znanstvenici na IRB (Distinguished Scientists at the RBI) Fries numbers of benzenoids - even faulty algorithms can be interesting (invited talk)

P. W. Fowler. Croatian Academy of Sciences and Arts, Invited lecture 'Aromaticity and counting', November 2012. (invited talk)

P. W. Fowler. Invited contributor to Fields Institute of Mathematics (Toronto) to meeting on mathematical aspects of Rigidity and Symmetry, Oct 2011 (invited talk)

M. Klin. conference SSAOS 2012 (High Tatras) see <https://sites.google.com/site/ssalgebra2012/program>  
Title: New non-Schurian association schemes with a few classes (invited talk)

W. Imrich. 13.-17. February, 2012. SODO 2012, Conference on "Symmetries of Discrete Objects". Queenstown, New Zealand  
Lecture "Distinguishing Infinite Graphs".

W. Imrich. 12. March, 2012, Lecture in Maribor "Distinguishing Infinite Graphs".

W. Imrich. 28.-31. March and 15.-19. April, 2012 (Blocked course, three weeks). AGH Cracow, "The direct product and large networks".

W. Imrich. 4. May till 14. June, 2012 Graph Theory Semester, University of Primorska, Koper, Slovenia  
Lectures on "Symmetry Breaking in Graphs"

W. Imrich. 24.-30. June, 2012. 3rd SYGN Workshop and 2012 PhD Summer School Discrete Mathematics Rogla, Slovenia

W. Imrich. 1.-5. Juli 2012. 6th European Congress of Mathematics, Cracow. Lecture "The endomorphism distinguishing number of graphs".

W. Imrich. 18. September, 2012. Lecture at Renyi Institute of the Academy of Sciences . in budapest on "Symmetry Breaking in Graphs".

W. Imrich. 20. September, 2012. 10 Years Bioinformatics Leipzig

W. Imrich. 1.-3. October 2012. International Symposium on Complex Network Analysis UMIT, Hall in Tirol Lecture on "Networks and Products of Graphs".

W. Imrich. 19. October 2012. Lecture in Klagenfurt "Netzwerke".

W. Imrich. 12. November 2012. Lecture University of Maribor "Symmetry Breaking in Graphs".

W. Imrich. 25. November until 7. December, 2012 (Two-week blocked course) in Cracow on "Symmetry breaking in graphs". (More detailed than in Koper.)

W. Imrich. 21st Workshop '3in1' 2012, Cracow, Poland. 29. November - 1. December 2012. Lecture "On the infinite Motion conjecture for Graphs and Groups".

D. Leemans: Symmetries of Discrete Objects 2012, Queenstown (New Zealand), February 13-17, 2012. Magma Minicourse on Permutation Groups, 2 lectures.

D. Leemans: New Zealand Mathematical Society Colloquium, Auckland (New Zealand), December 6-8, 2011. Polytopes of high rank for the symmetric groups.

D. Leemans: Workshop on Symmetry, Graphs and Polytopes, Fields Institute, Toronto (Canada), October 24-27, 2011. Plenary talk. Polytopes of high rank arising from almost simple groups.

D. Leemans: Seventh Slovenian International Conference on Graph Theory, Bled (Slovenia), June 20-25, 2011. Chirally regular polytopes.

D. Leemans: 5th De Bruin Workshop on Groups, Combinatorics and Computing, NUI Galway (Ireland), April 11-16, 2011. Searching for Geometries with Magma.

Leydold, Josef. 2011. Convex Cycle Bases and Cartesian Products. 25th LL-Seminar on Graph Theory, Leoben, Österreich, 23.09.-24.09.

Leydold, Josef. 2012. Generating Generalized Inverse Gaussian Distributed Random Variates. Monte Carlo and Quasi-Monte Carlo Methods 2012, Sydney, Australien, 13.02.-17.02.

Leydold, Josef. 2011. Convex Cycle Bases. 7th Slovenian International Conference on Graph Theory, Bled, Slowenien, 20.06.-24.06.

Lecture at IWONT 2014 Bratislava June 30 - July 4, Patrick Fowler (The University of Sheffield), Why chemists care about graph theory?

Invited Plenary Speaker at MAGIC (Workshop on Magnetically Induced Currents in Chemistry, University of Helsinki, Tvarminne, Finland, Nov 17-21 2014), Patrick Fowler: The orbital view: selection rules for ring-current aromaticity.

M. Conder. 'More on symmetric regular covers of graphs'. Presented at Workshop on Algebraic, Topological and Complexity Aspects of Graph Covers (ATCAGC 2013), Bovec, Slovenia. January 2013.

M. Conder. 'Some unexpected consequences of computation with groups'. Presented at Retirement Symposium for Tom Tucker, Colgate University, Hamilton NY. April 2013.

M. Conder. 'Discrete objects with maximum possible symmetry'. Presented at American Mathematical Society meeting, Boston, MA. 6 April - 7 April 2013.

M. Conder. 'Half-arc-transitive and semi-symmetric graphs'. Presented at International Conference on Graph Theory & Combinatorics, Koper, Slovenia. May 2013.

M. Conder. 'Graph Symmetries'. Presented at PhD summer school on Discrete Mathematics, Rogla, Slovenia. June 2013.

M. Conder. 'An update on polytopes with many symmetries'. Presented at Retrospective Workshop on Discrete Geometry, Optimization & Symmetry, Fields Institute, Toronto. November 2013.

M. Conder. 'Embeddings of circulants on surfaces'. Presented at 37th Australasian Conference on Combinatorial Mathematics & Combinatorial Computing (37ACCMCC), Perth, Australia. December 2013.

M. Conder. 'Embeddings of circulants on surfaces'. Presented at Annual Meeting of the American Math Society,

Baltimore MD, USA. January 2014.

M. Conder. 'Regular maps with simple underlying graph'. Presented at Algebraic, Topological and Complexity Aspects of Graph Covers, Ostravice, Czech Republic. January 2014.

M. Conder. 'Extreme graph symmetries'. Presented at Algebraic Combinatorics: Spectral Graph Theory, Erdős-Ko-Rado Theorems and Quantum Information Theory, Waterloo, Canada. June 2014.

M. Conder. 'Skew morphisms of groups'. Presented at Symmetries of Graphs and Networks IV, Rogla, Slovenia. June 2014.

M. Conder. 'Recent developments in the study of regular maps'. Presented at Symmetries In Graph, Maps And Polytopes (SIGMAP'14) - plenary lecture, West Malvern, UK. July 2014.

M. Conder. 'Minimum genus embeddings of vertex-transitive graphs'. Presented at Embedded Graphs, Euler Mathematical Institute, St Petersburg, Russia. October 2014.

- Posters

Computers in Scientific Discovery conference, August 2012, Portoroz (Slovenia) //

Ivona Puljic: Upper and lower bound for Roman domination number of cardinal product of paths, (which was a joint work with Croatian PI Antoaneta Klobucar)

CSASC Conference, Koper, Slovenia, Juny 2013. Antoaneta Klobučar "Some results for Roman domination number on cardinal products of paths and cycles" (joint work with Ivona Puljić)

M. Cerinšek, J. Bodlaj, V. Batagelj, Symbolic clustering of users and antennae, 3rd Conference on the Analysis of Mobile Phone Datasets, NetMob 2013, Cambridge (Massachusetts), USA, May 2013, Mobile phone data for development : analysis of mobile phone datasets for the development of Ivory Coast, 211–226.

J. Bodlaj, M. Cerinšek, V. Batagelj, Visualization of traffic, 3rd Conference on the Analysis of Mobile Phone Datasets, NetMob 2013, Cambridge (Massachusetts), USA, May 2013, Mobile phone data for development : analysis of mobile phone datasets for the development of Ivory Coast, 480–495.

- Other (*please define*)

Balakrishnan, R. and Bapat, R. B. and Klavžzar, Sandi and, Preface [Recent trends in graph theory and combinatorics]. Discrete Math. 312 (2012), 1493. <http://dx.doi.org/10.1016/j.disc.2011.12.025> (Introduction)

Bratislava Graph Theory Seminar (Regular seminar on graph theory and combinatorics)

Head of the seminar: Martin Skoviera Weekly (during the semester) at Comenius University, Bratislava Slovakia

Seminar for Discrete Matematics, Institute of Mathematics, Physics and Mechanics, Ljubljana. Head of the seminar: Tomaž Pisanski.

Annual meeting of the slovak part of the GReGAS team. December 5 to 12 2011 and December 11 to 15 2012 Mosonmagyarovar, Hungary

AGT in BB Algebraic Graph Theory in Banska Bystrica, August/September 2012, Matej Bel University, Banska Bystrica Slovakia

- Programme Committee: Mikhail Klin, Roman Nedela and Martin Macaj (all members of GReGAS)
- Organizing Committee: Martin Macaj, Jan Karabas (both GReGAS) and Stefan Gyurki

In addition, Slovenian PL and PI teams achieved the following:

- Organization of the conference Computers in Scientific Discovery with a plenary speaker, prof. Harold Kroto, nobel laureate (discovery of C60 fulleren)
- proj. member prof. Konvalinka received award of University of Ljubljana given to best teachers.
- A project financed by Picker Institute (USA, Colgate University) continued into the 2nd year as the results for the first year were very good.

- Pisanski appointed to the Publications Committee of European Mathematical Society.
- PI prof. Marusic was elected as rector of the University of Primorska.
- project member prof. Miklavic received national award for science (Zois prize).
- V. Batagelj has received INSNA's William D. Richards Jr., Software Award (2013) for Pajek software

Unpublished lecture: Leydold, Josef. 2012. Sign patterns of graph laplacian eigenvectors. Istanbul Discrete Mathematics Meetings, Istanbul, 27.04.

Bratislava Graph Theory seminar (lead by Prof. M. Škoviera),  
<http://new.dcs.fmph.uniba.sk/index.php/Seminare/SeminarZTeorieGrafov>

Regular seminar in Banska Bystrica: "Aka si mi krasna" (lead by doc. M. Haviar),  
<http://www.akasimikrasna.sk>

R. Nedela: Why mathematicians compute maps? MIST conference, Kæak, 7.-12. 1. 2013.

J. Širan: Fruits of ploughing fields along elliptic curves, MIST conference, Klak, 7.-12. 1. 2013.

### Public outreach

- Press releases

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- National / international newspaper articles (presenting your CRP or part of your work)

Article related to the conference and EUROGIGA networking event and especially about nobelist Sir Harald Kroto visiting Slovenia having talk at CSD 6 conference.

- <http://www.dnevnik.si/magazin/znanost-in-tehnologija/1042548265>
- [http://www.primorska.info/novice/18840/nobelovec\\_kroto\\_predaval\\_na\\_turisticih](http://www.primorska.info/novice/18840/nobelovec_kroto_predaval_na_turisticih)
- <http://www.slomedia.it/dr-kroto-znanost-je-predvsem-nacin-razmisljanja>

- TV appearance

Croatian Academy of Sciences and Arts, Invited lecture 'Aromaticity and counting', November 2012. (invited talk)

Short interview about this second lecture was recorded for Croatian TV

- Radio appearance

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- Other (*please define*)

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### Other activities / outputs

- Patents

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- Websites

<http://www.gregas.eu> - Official project web site  
<http://atlas.gregas.eu> - Encyclopedia of graphs web site

- Other (*please define*)

- Abelium team:
  - in 2012 won Slovenian innovation award for the most innovative service iOliva (geometric graph theory application)

- in 2013 won Slovenian innovation award for the most innovative business model (use of graph theory and optimization in logistics for cooperation in GoOpti solution: Abelium team and TMVista company)
- In 2014, finalist of the Cloud Innovation World Cup (one of the four finalists for Allianz Evolve Award, Abelium & TM Vista)
- In 2014 winner of Eurocloud Europe Award for the cloud solution with the best business impact (Goopti solution, Abelium & TMVista)

**B.5. Feedback on the EUROCORES programme and EUROCORES scheme (up to 300 words)**

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## Section C. Self-assessment and follow-up

### C.1. Overall self assessment on the accomplishments of the CRP (up to 600 words)

Initially not all PI members of the project were approved by their respective countries, among them J. Leydold from Austria and D. Leemans from Belgium. Professor Leydold then continued to work as a member of the PI Stadler, while D. Leemans moved to New Zealand and continued cooperation through the team of AP Conder. Thus, even without all the PIs from the initial application, the work on the project started successfully. After that the project was carried out according to the plan in the application without any major deviations. For a brief period there was unclear situation in regard to financing of PI Biyikoglu, which was eventually resolved. Funding was temporarily stopped or reduced due to government budget cuts addressing the economic crisis in Croatia and Slovenia. Financing issues made the work on the project harder but did not have a major impact on the course of the project.

Beside the topics stated in the application the course of the research has even extended, especially in the part of applications in chemistry, bioinformatics and large networks.

The reporting related to the project was carried out on national levels according to the reporting obligations of the respective national research agencies. We have successfully submitted the midterm report to ESF and received a positive feedback.

The CRP contributed significantly in strengthening research and cooperation ties, which were built in the past through series of periodic conferences and workshops, existing personal collaboration and common scientific journal *Ars Mathematica Contemporanea*. After the start of indexing by SCIE in 2011, the journal grew stronger and in 2015 we plan to double the number of issues per year (4 instead of 2). The work in CRP contributed significantly towards this achievement.

The teams of Slovenian PIs involved cooperation of all three major universities in Slovenia and also a research oriented company Abelium, which is kind of a spin-off from the two universities (University of Ljubljana, University of Primorska). Thus the research and development received the motivation from industry especially related to applications of large networks in logistics.

The project offered a strong funding support for the groups involved, which could in this way continue and expand their scientific work. During this period all groups have supported several young scientists, some of them very progressive ones.

### C.2. Follow-up activities emerged as a result of the CRP and the programme (up to 300 words)

New applications of graph representations in chemistry and synthetic biology were identified. An application to the ERASynBio1 call was sent and a project BioOrigami was approved, starting in 2015, includes PI Pisanski. PI Pisanski and PI Klavžar become involved in research in applications of graph and representation theory in synthetic biology. Several papers were published already.

The journal established by the groups involved in the CRP, *Ars Mathematica Contemporanea*, grew stronger and in 2015 we plan to double the number of issues per year from 2 to 4.

The work on evolution in networks opened new research directions, especially considering the motivation from the "Big-data" industry. New initiative related to formalization and software development, similar to the one of Pajek from the 90s, have started in 2014. As a result of this, two new prototype software libraries, TQ and Ianus were developed and the ideas presented on relevant international conferences.

We have started to work on graph modelling of multi party off-the-record communication with Berkant Ustaoglu (Izmir Institute of Technology). Based on the results of the CRP, proposal for the prestigious TUBITAK 1003 - Primary Subjects R&D Funding Program was submitted and is currently pending in the second round.

De novo Peptide Sequencing is an important problem in computational mass spectrometry based proteomics. In cooperation with Jens Allmer Bioinformatics group Izmir Institute of Technology we have efficiently solved de novo sequencing problem with a new novel linear time algorithm as a result of this CRP. Jens Allmer has a start-up company funded by TUBITAK. Our results have shown a huge economical potential and also potential for future research funding.

Bilateral project Slovenia-Croatia has been established, with the leaders Damir Vukičević and Dragan Stevanović. "Adriatic Conference on Graph Theory and Complexity" was held for the first time (in Split, Croatia, April 2014.).

### **C.3. Forward looking perspectives enabled by the programme (up to 300 words)**

During the time of the duration of the CRP, the general R&D focus in EU have changed significantly and positively - problems from the real-world, industry and business are becoming increasingly important motivator for R&D. Consequently, the research is becoming more and more multidisciplinary. This move is clearly seen in the orientation of the Horizon 2020 calls and work programmes.

We are glad that this has reflected within our CRP as well, since our research became increasingly more motivated toward R&D and applications in synthetic biology, chemistry, bioinformatics, Big-data, data science and logistics. This expansion from basic research towards interdisciplinary collaboration and applications, while still keeping strong "basic" component, opens up opportunities for involving mathematicians in Horizon 2020 projects and similar. For mathematicians it is often difficult to involve into EU projects like the ones of FP6 and FP7. The kind of projects like EUROGiga are important initiatives, which together with multidisciplinary pressure from the Horizon's 2020 side, opens up the space for involving mathematicians into R&D possibly having much bigger socio-economic impact. So we strongly support future initiatives similar to EUROCORES/EUROGiga.

## **Priloga 3**

**VEDA / Področje / Podpodročje:**

**1.07.01/Naravoslovno-matematične vede/Računalniško intenzivne metode in aplikacije/Algoritmi**

**Dosežek:** GÓMEZ-NÚÑEZ, Antonio J., BATAGELJ, Vladimir, VARGAS-QUESADA, Benjamín, MOYA-ANEGÓN, Félix de, CHINCHILLA-RODRÍGUEZ, Zaida. Optimizing SCImago Journal & Country Rank classification by community detection. *Journal of Informetrics*, ISSN 1751-1577, 2014, vol. 8, iss. 2, str. 369-383.

<http://dx.doi.org/10.1016/j.joi.2014.01.011>. [COBISS.SI-ID [17105241](#)]

kategorija: 1A1 (Z, A", A', A1/2); uvrstitev: SSCI, Scopus (d), Scopus, MBP; tipologijo je verificiral OSICD

**Vir:** <http://dx.doi.org/10.1016/j.joi.2014.01.011>



**Povzetek:** Klasifikacija predstavlja pomembno temo v bibliometriji in scientometriji. Želimo si zanesljivih in doslednih orodij ter rezultatov. Takšni cilji zahtevajo dobro opredeljen sistem razvrščanja po osnovnem predmetu, ki ustrezno odraža znanstvena področja. V širšem naboru tehnik razvrščanja so metode za razvrščanje (ang. cluster analysis) ene izmed najbolj uspešnih metod. Dva algoritma za razvrščanje, ki temeljita na modularnosti - metodi VOS in Louvain - sta predstavljena z namenom posodobitve in optimizacije razvrstitev na platformi SCImago Journal & Country Rank (SJR). Uporabili smo orodje za analizo in vizualizacijo omrežij Pajek in zagnali oba algoritma na omrežju z več kot 18.000 revij v SJR, ki združuje tri mere za neposredno citiranje, sosclic in sklicno sklopljenost. Množica tako pridobljenih skupin je bila poimenovana po kategorijah oznak, dodeljenih revijam v SJR in po pomembnih besedah iz naslovov revij. Kljub temu, da rezultata obeh algoritmov odražata majhne razlike, rezultati kažejo podobno obnašanje pri združevanju revij. Zato predstavljata ustrezni rešitvi za namene razvrščanja. Na novo ustvarjeni klasifikaciji temelječi na dveh algoritmih smo primerjali z drugimi bibliografskimi sistemi razvrščanja, vključno z originalnimi predmetnimi kategorijami v SJR in WoS, da bi preverili njihovo skladnost, ustreznost in natančnost. Poleg nekaterih pomembnih razlik, smo identificirali določeno povezanost in homogenost med štirimi analiziranimi sistemi za klasifikacijo.