

## UČNI NAČRT PREDMETA / COURSE SYLLABUS

<b>Predmet:</b>	Kognitivni radio in omreženje
<b>Course title:</b>	Cognitive Radio and Networking

Študijski program in stopnja Study programme and level	Modul Module	Letnik Academic year	Semester Semester
Informacijske in komunikacijske tehnologije, 3. stopnja	Komunikacijske tehnologije	1	1
Information and Communication Technologies, 3 <sup>rd</sup> cycle	Communication Technologies	1	1

**Vrsta predmeta / Course type** Izbirni / Elective

**Univerzitetna koda predmeta / University course code:** IKT3-647

Predavanja Lectures	Seminar Seminar	Sem. vaje Tutorial	Lab. vaje Laboratory work	Druge oblike	Samost. delo Individ. work	ECTS
15	15			15	105	5

*\*Navedena porazdelitev ur velja, če je vpisanih vsaj 15 študentov. Drugače se obseg izvedbe kontaktnih ur sorazmerno zmanjša in prenese v samostojno delo. / This distribution of hours is valid if at least 15 students are enrolled. Otherwise the contact hours are linearly reduced and transferred to individual work.*

**Nosilec predmeta / Lecturer:** Prof. dr. Mihael Mohorčič

**Jeziki / Predavanja / Lectures:** Slovenščina, angleščina / Slovenian, English  
**Languages: Vaje / Tutorial:**

**Pogoji za vključitev v delo oz. za opravljanje študijskih obveznosti:**

Zaključen študij druge stopnje s področja informacijskih ali komunikacijskih tehnologij ali zaključen študij druge stopnje na drugih področjih z znanjem osnov s področja predmeta. Potrebna so tudi osnovna znanja matematike, računalništva in informatike.

**Prerequisites:**

Completed second cycle studies in information or communication technologies or completed second cycle studies in other fields with knowledge of fundamentals in the field of this course. Basic knowledge of mathematics, computer science and informatics is also requested.

**Vsebina:**

Uvod:  
 kognitivnost v komunikacijskih sistemih, motivacija za uvajanje kognitivnosti, uvajanje kognitivnosti v komunikacijske sisteme  
 Osnovni koncept kognitivnih komunikacij:  
 programirljivi radio, kognitivni radio, arhitektura in osnovna funkcionalnost kognitivnega radia, kognitivni cikel, obseg kognitivnih funkcionalnosti, reprezentacija znanja  
 Kognitivna radijska omrežja:

**Content (Syllabus outline):**

Introduction:  
 cognition in communication systems, motivation for going cognitive, scope of cognitive functionality  
 Basic Concept of Cognitive Communications:  
 software defined radio, cognitive radio, architecture and basic functionality of cognitive radio and networks, cognition cycle, knowledge representation

zaznavanje radijskega spektra, dinamični dostop do radijskega spektra, priložnostni dostop do radijskega spektra, souporaba radijskega spektra, upravljanje radijskih virov in radijskega okolja v heterogenih brezžičnih dostopovnih omrežjih, medplastno načrtovanje

Kognitivna omrežja:

samozavedanje (lokacija, storitve, kontekst, itd), samodejno upravljanje omrežja, sestavljanje prenosnih storitev

Standardizacija in raziskovalni izzivi

Cognitive Radio Networks:

spectrum sensing, dynamic spectrum access, opportunistic spectrum access, spectrum sharing, radio resource management and radio environment management in heterogeneous wireless access networks, cross-layer design

Cognitive Networks:

self-awareness (location, service, context, etc), autonomous network management, transport service composition

Standardisation and Research Challenges

### Temeljna literatura in viri / Readings:

Izbrana poglavja iz naslednjih knjig: / Selected chapters from the following books:

- Q. Mahmoud (Ed.), *Cognitive Networks – Towards Self-Aware Networks*, Wiley, 2007. ISBN 978-0-470-06196-1
- K.-C. Chen, R. Prasad, *Cognitive radio networks*, Wiley, 2009. ISBN 978-0-470-69689-7
- L. Berlemann, S. Mangold, *Cognitive radio for dynamic spectrum access*, Wiley, 2009. ISBN 978-0-470-51167-1
- A.M. Wyglinski (Ed.), M. Nekovee (Ed.), Y.T. Hou (Ed.), *Cognitive radio communications and networks: principles and practice*, Elsevier : Academic Press, 2010. ISBN 978-0-12-374715-0
- R.W. Thomas, *Cognitive Networks*, PhD Dissertation, Virginia Tech, Blacksburg, Virginia, June 15, 2007.

### Cilji in kompetence:

V okviru predmeta se bodo študenti seznanili s konceptom uvajanja kognitivnih tehnik v sodobne telekomunikacijske sisteme. Poudarek bo na naprednih tehnikah, arhitekturah in postopkih za izboljševanje izkoriščanja radijskega spektra, prenosnih virov in komunikacijskih vmesnikov ter na samodejnem upravljanju storitev in omrežja.

Cilji predmeta so (1) študente seznaniti z osnovnim konceptom uvajanja kognitivnih tehnik v brezžična in radijska omrežja, (2) predstaviti osnovno arhitekturo in funkcionalnost kognitivnih radijskih omrežij, (3) pregledati tehnike in postopke, ki se uporabljajo v kognitivnih radijih in omrežjih, in (4) predstaviti osnove koncepta avtonomnega upravljanja komunikacijskega omrežja.

Študenti bodo razvili sposobnost samostojnega raziskovalnega in razvojnega dela na področju kognitivnega radija in omrežja, ki vključuje načrtovanje, preskušanje in vrednotenje osnovnih postopkov kognitivnega delovanja komunikacijskih sistemov.

### Objectives and competences:

This course will introduce students into the concept of using cognitive techniques in contemporary telecommunication systems. The emphasis will be on advanced techniques, architectures and procedures for improvement of radio spectrum efficiency and resource management, for context-aware utilisation of communication interfaces and for autonomous management of networks and services.

The course objectives are to (1) introduce students with the concept of using cognitive techniques in wireless and radio networks, (2) present the basic architecture and functionalities of cognitive radio networks, (3) provide an overview of techniques and procedures used in cognitive radio and networks and (4) present the concept of autonomous network management.

Students will develop the ability to solve independent research and development tasks in the field of cognitive radio and networking, including design, testing and performance evaluation of basic procedures used in cognitive radio and networks.

**Predvideni študijski rezultati:**

Študent, ki bo uspešno končal ta predmet, bo pridobil:

- poznavanje koncepta kognitivnosti v komunikacijskih vozliščih in omrežjih in potrebe po njegovem uvajanju z namenom povečanja izkoristka omejenih prenosnih virov
- sposobnost narediti omrežja bolj avtonomna in samozavedujoča
- znanje o osnovnih gradnikih kognitivnega cikla in njihove vloge
- usposobljenost za načrtovanje izbranih osnovnih postopkov za uporabo v kognitivnem radiju in omrežjih.

**Intended learning outcomes:**

A student who completes this course successfully will acquire:

- the concept of cognitive radio networking and will understand the reason for introducing cognitive techniques in communication nodes and networks with the aim to improve the utilisation efficiency of transmission resources
- the ability to make communication networks more autonomous and self-aware
- understanding of basic building blocks of cognition cycle and their role,
- capability of designing selected basic procedures used in cognitive radio and networks.

**Metode poučevanja in učenja:**

Predavanja, seminar, konzultacije, individualno delo

**Learning and teaching methods:**

Lectures, seminar, consultancy, individual work

**Načini ocenjevanja:**

Delež (v %) /

Weight (in %)

**Assessment:**

Seminarska naloga	50 %	Seminar work
Ustni zagovor seminarske naloge	50 %	Oral defense of seminar work

**Reference nosilca / Lecturer's references:**

- C. Fortuna, A. Bekan, T. Javornik, G. Cerar, **M. Mohorcic**, "Software interfaces for control, optimization and update of 5G machine type communication networks", *Computer networks : the international journal of computer and telecommunications networking*, ISSN 1389-1286. [Print ed.], 2017, vol. 129, part 2, pp. 373-383, doi: [10.1016/j.comnet.2017.06.015](https://doi.org/10.1016/j.comnet.2017.06.015).
- M. Sociu, T. Solc, L. Cremene, **M. Mohorcic**, C. Fortuna, "Discrete transmit power devices in dense wireless networks : methodology and case study", *IEEE access*, ISSN 2169-3536, 2017, vol. 5, pp. 1762-1778, doi: [10.1109/ACCESS.2017.2669403](https://doi.org/10.1109/ACCESS.2017.2669403).
- C. Fortuna, **M. Mohorčič**, "A framework for dynamic composition of communication services", *ACM transactions on sensor networks*, vol. 11, no. 2, pp. 31-1-31.10, 2014.
- T. Šolc, C. Fortuna, **M. Mohorčič**, "Low-cost testbed development and its applications in cognitive radio prototyping". V: M.-G. di Benedetto, ed. *Cognitive radio and networking for heterogeneous wireless networks: recent advances in visions for the future*, Springer, 2015, pp. 361-405. ISBN 978-3-319-01718-1
- M. Pesko, T. Javornik, L. Vidmar, A. Košir, M. Štular, **M. Mohorčič**, "The indirect self-tuning method for constructing radio environment map using omnidirectional or directional transmitter antenna", *EURASIP Journal on wireless communications and networking*, 2015, 12 pp., doi: [10.1186/s13638-015-0297-2](https://doi.org/10.1186/s13638-015-0297-2).