

**UČNI NAČRT PREDMETA / COURSE SYLLABUS**

**Predmet:** Visokozmogljivi računalniški sistemi  
**Course title:** High Performance Computing Systems

Študijski program in stopnja Study programme and level	Študijska smer Study field	Letnik Academic year	Semester Semester
Računalništvo in spletne tehnologije, visokošolski strokovni študijski program prve stopnje	-	Drugi ali tretji	Četrta ali šesta
Computer Science and Web Technologies, first cycle Professional Study Programme	-	Second or third	Fourth or sixth

**Vrsta predmeta / Course type**

Izbirni / Elective

**Univerzitetna koda predmeta / University course code:**

2-RST-VS-IP-VZRS-2020-05-14

Predavanja Lectures	Seminar Seminar	Vaje Tutorial	Klinične vaje work	Druge oblike študija	Samost. delo Individ. work	ECTS
30	-	45	-	-	105	6

**Nosilec predmeta / Lecturer:**

doc. dr. Bernard Ženko, izr. prof. dr. Biljana Mileva Boshkoska

**Jeziki / Languages:**

**Predavanja / Lectures:** Slovenski / Slovenian, Angleški / English

**Vaje / Tutorial:** Slovenski / Slovenian, Angleški / English

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

Opravljen izpit Uvod v programiranje.

**Prerequisites:**

Passed exam Introduction to Programming.

**Vsebina:**

- *Uvod:*  
Visokozmogljivo računalništvo (HPC), na nivoju strojne opreme, operacijskih sistemov in izvajalnih okolij, programske opreme. Področja uporabe HPC, zgodovina in prihodnji trendi.
- *Strojna oprema:*  
Procesorji, pospeševalniki, mrežna oprema, in hlajenje. Tipične obstoječe rešitve, njihove lastnosti in posledice za

**Content (Syllabus outline):**

- *Introduction:*  
High Performance Computing (HPC) on the level of hardware, operating systems and runtime environments, and software. History of HPC, fields of use, and future trends.
- *Hardware:*  
Processors, accelerators, networking and cooling. Typical solutions to hardware challenges, their properties

<p>uporabnike. Nivoji vzporednosti, ki jih implementira strojna oprema.</p> <ul style="list-style-type: none"> <li>• <i>Izvajalno okolje:</i> Načini dela na HPC opremi. Administriranje ter uporaba velikih računalniških sistemov. Uporaba računalništva v oblaku.</li> <li>• <i>Programska oprema:</i> Značilnosti programske opreme za HPC, s poudarkom na vzporednem in porazdeljenem izvajanju. Uporaba knjižnic za vzporedno in porazdeljeno računanje: MPI, OpenMP in ZeroMQ, direktna uporaba niti, vtičnic in vektorskih (SIMD) ukazov.</li> <li>• <i>Vzporedni algoritmi:</i> Tipi vzporednosti v algoritmih, njihove lastnosti in načini izkoriščanja. Tipični vzporedni algoritmi ter njihova uporaba.</li> </ul>	<p>and consequences felt by HPS users. Levels of hardware parallelism.</p> <ul style="list-style-type: none"> <li>• <i>Runtime environments:</i> Working on a HPC system. Administration and use of large computer systems. Use of cloud computing and HPC cloud computing.</li> <li>• <i>Software:</i> Main properties of HPS software, emphasis on the parallel and distributed execution. Guidance on the use of parallel and distributed computing libraries: MPI, OpenMP, ZeroMQ. Direct use of low level tools, such as threads, processes, sockets, and vector (SIMD) instructions.</li> <li>• <i>Parallel algorithms:</i> Levels of parallelism in algorithms, their properties and methods of exploitation. Some typical and widely used parallel algorithms.</li> </ul>
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#### Temeljni literatura in viri / Readings:

- Foster, I. (1996). *Designing and Building Parallel Programs*. Addison-Wesley.
- Grama, A., Gupta, A., Karypis, G. & Kumar, V. (2003). *Introduction to Parallel Computing* (2nd ed.). Addison Wesley.
- Hintjens, P. (2013). *ZeroMQ Messaging for Many Applications*. O'Reilly Media.
- Trobec, R., Vajtersic, M. & Zinterhof, P. (2009). *Parallel Computing Numerics, Applications, and Trends*. Springer.
- Trobec, R., Slivnik, B., Bulić, P. & Robič, B. (2018). *Introduction to Parallel Computing. From Algorithms to Programming on State-of-the-Art Platforms*. Springer.

#### Cilji in kompetence:

*Učna enota prispeva k razvoju naslednjih splošnih in predmetno-specifičnih kompetenc:*

##### *Splošne kompetence:*

- usposobljenost za delo s HPC sistemi, v vlogi administratorja, uporabnika in razvijalca aplikacij
- obvladovanje hitro razvijajočega se področja visokozmogljivega računanja in sodelovanje v njem
- sposobnost razvoja vzporednih algoritmov
- sposobnost izkoriščanja vzporednih sistemov, več-jedrnih procesorjev, vektorskih operacij pri programiranju visoko zmogljivih aplikacij

#### Objectives and competences:

*The instructional unit contributes to the development of the following general and subject-specific competences:*

##### *General competences:*

- competence to work with the HPC, either as an administrator, a user, or a developer
- confidence in the rapidly expanding area of HPC and the competence to contribute to it
- ability to develop parallel algorithms
- ability to use parallel systems, multi-core processors, and vector instructions in the development of HPC applications

##### *Subject-specific competences:*

**Predmetno- specifične kompetence:**

- poznavanje najbolj pogostih programskih tehnik za vzporedno programiranje
- poznavanje področja HPC ter znanje potrebno za delo na HPC sistemu

- familiarity with the basic techniques for parallel programming
- familiarity with the field of HPC and the expertise for working with all levels of the HPC

**Predvideni študijski rezultati:**

Študent/študentka:

- pozna ključne vzporedne algoritme in tehnike s področja vzporednega programiranja
- je seznanjen(a) z konceptom dela na velikem računalniškem sistemu, z razlogi, ki vodijo do takega koncepta in ima izkušnje z delom na konkretnem sistemu

**Intended learning outcomes:**

The student:

- is familiar with algorithms and techniques relating to the field of parallel computing
- is equipped with theoretical concepts of working on large computer systems, the background that led to such concepts, and possesses experience with working on a specific system

**Metode poučevanja in učenja:**

- predavanja z aktivno udeležbo študentov (*razlaga, diskusija, vprašanja, primeri, reševanje problemov*)
- vaje v računalniški učilnici: pri teh vajah bodo študentje preizkusili konkretne vzporedne algoritme, metode za paralelizacijo in najbolj razširjene knjižnice za uporabo HPC. Vaje bodo potekale v manjših skupinah, tako da bo imel vsak študent na razpolago en računalnik
- domače naloge in projektna naloga – z domačimi nalogami bo študent(ka) preko samostojnega dela utrdil(a) vse znanje, ki ga je pridobil na predavanjih in vajah. S projektno nalogo bo to dokazal(a) znanje in sposobnost povezovanja naučenih metod v večjo celoto

**Learning and teaching methods:**

- lectures with active student participation (explanation, discussion, questions, examples, problem solving)
- tutorials in computer lab (laboratory practice) allow the students to test specific parallel algorithms, methods of parallelization and the most widely used libraries for HPC use. The tutorials will be performed in small groups, allowing each student to have access to own computer
- home assignments and project assignment will allow students to strengthen knowledge acquired during lectures and tutorials through individual work. The project assignment will also test their ability of connecting the learned methods into a larger system

Delež (v %) /

Weight (in %) /

**Načini ocenjevanja:****Assessment:**

Način (pisni izpit, ustno izpraševanje, naloge, projekt):

Type (examination, oral, coursework, project):

- pisni izpit
- domače naloge
- projektna naloga

40  
20  
40

- written exam
- home assignments
- project assignment

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

- DEBELJAK, MARKO, POLJANEC, ALEŠ, in ŽENKO, BERNARD (2014) Modelling forest growing stock from inventory data: a data mining approach. *Ecological indicators*, 41, str. 30-39.
- PETKOVIĆ, Matej, BOUMGHAR, Redouane, BRESKVAR, Martin, DŽEROSKI, Sašo, KOCEV, Dragi, BOUMGHAR, Redouane, LEVATIĆ, Jurica, LUCAS, Luke, OSOJNIK, Aljaž, ŽENKO, Bernard, SIMIDJIEVSKI, Nikola. Machine learning for predicting thermal power consumption of the Mars Express spacecraft. *IEEE aerospace and electronic systems magazine*, ISSN 0885-8985, 2019, vol. 34, no. 7, str. 46-60, doi: 10.1109/MAES.2019.2915456.
- STROJNIK, Lidija, STOPAR, Matej, ZLATIĆ, Emil, KOKALJ, Doris, NAGLIČ GRIL, Mateja, ŽENKO, Bernard, ŽNIDARŠIČ, Martin, BOHANEK, Marko, MILEVA BOSHKOSKA, Biljana, LUŠTREK, Mitja, GRADIŠEK, Anton, POTOČNIK, Doris, OGRINC, Nives. Authentication of key aroma compounds in apple using stable isotope approach. *Food chemistry*, ISSN 0308-8146. [Print ed.], 2019, vol. 277, str. 766-773, doi: 10.1016/j.foodchem.2018.10.140.
- GRAU LEGUIA, Marc, LEVNAJIĆ, Zoran, TODOROVSKI, Ljupčo, ŽENKO, Bernard. Reconstructing dynamical networks via feature ranking. *Chaos*, ISSN 1054-1500, 2019, vol. 29, no. 9, str. 09310-1-093107-15, doi: 10.1063/1.5092170.
- MILEVA BOSHKOSKA, Biljana, LIU, Shaofeng, ZHAO, Guoqing, FERNANDEZ, Alejandro, GAMBOA, Susana, PINO, Mariana del, ZARATÉ, Pascale, HERNANDEZ, Jorge, CHEN, Huilan. A decision support system for evaluation of the knowledge sharing crossing boundaries in agri-food value chains. *Computers in industry*, ISSN 0166-3615. [Print ed.], 2019, vol. 110, str. 64-80, doi: 10.1016/j.compind.2019.04.012.
- BOŠKOSKI, Pavle, DEBENJAK, Andrej, MILEVA BOSHKOSKA, Biljana. Rayleigh copula for describing impedance data - with application to condition monitoring of proton exchange membrane fuel cells. *European journal of operational research*, ISSN 0377-2217. [Print ed.], 2018, vol. 266, no. 1, str. 269-277, doi: 10.1016/j.ejor.2017.08.058.