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
Informatika v sodobni družbi, visokošolski strokovni študijski program prve stopnje	-	Drugi	Četrti
Informatics in Contemporary Society, first cycle Professional Study Programme	-	Second	Fourth

Vrsta predmeta / Course type	Izbirni / Elective

Univerzitetna koda predmeta / University course code:	1-ISD-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:	**Prerequisits:**
Opravljen izpit Uvod v programiranje.	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 uporabnike. Nivoji vzporednosti, ki jih implementira strojna oprema.

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 and consequences felt by HPS users. Levels of hardware parallelism.

- *Izvajalno okolje:*
  Načini dela na HPC opremi.
  Administriranje ter uporaba velikih
  računalniških sistemov. Uporaba
  računalništva v oblaku.
- *Programska oprema:*
  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.
- *Vzporedni algoritmi:*
  Tipi vzporednosti v algoritmih, njihove
  lastnosti in načini izkoriščanja. Tipični
  vzporedni algoritmi ter njihova
  uporaba.

- *Runtime environments:*
  Working on a HPC system. Administration
  and use of large computer systems. Use
  of cloud computing and HPC cloud
  computing.
- *Software:*
  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.
- *Parallel algorithms:*
  Levels of parallelism in algorithms, their
  properties and methods of exploitation.
  Some typical and widely used parallel
  algorithms.

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., Vajteršic, 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:

- poznavanje in razumevanje širokega nabora aplikacij informacijsko komunikacijske tehnologije v sodobni družbi
- razvoj in uporaba informacijsko komunikacijske tehnologije, sposobnosti in spretnosti v lokalnem in mednarodnem okolju
- sposobnost zapisati problem v obliki algoritma in pretvorba algoritma v računalniški program z uporabo sodobnih programskih orodij
- razumevanje in uporaba računalniških sistemov in arhitektur

Objectives and competences:

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

- knowledge and understanding of a wide range of applications of information communication technology in the modern society
- development and the use of ICT, ability and skills in local and international environment
- the ability to write the problem in the form of an algorithm and converting the algorithm into a computer program using modern programming tools
- understanding and use of computer systems and architectures

Predvideni študijski rezultati:	Intended learning outcomes:
Znanje in razumevanje: *Študent/študentka:* • pozna ključne vzporedne algoritme in tehnike s področja vzporednega programiranja • je seznanjen(a) s konceptom dela na velikem računalniškem sistemu, z razlogi, ki vodijo do takega koncepta in ima izkušnje z delom na konkretnim sistemu	Knowledge and understanding: *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:	Learning and teaching methods:
• *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	• *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

Načini ocenjevanja:	Delež (v %) / Weight (in %)	Assessment:
Način (pisni izpit, ustno izpraševanje, naloge, projekt):		Type (examination, oral, coursework, project):
• pisni izpit	40	• written exam
• domače naloge	20	• home assignments
• projektna naloga	40	• 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, BOHANEC, 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, HERNANDÉZ, 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.