INFOTEHNOLOOGIA TEADUSKOND
ARVUTITEHNIKA INSTITUUT
TEADUS- JA ARENDUSTEGEVUSE AASTAARUANNE 2014

1. Arvutitehnika instituudi struktuur

Arvutitehnika instituuti kuulub kaks uurimisgruppi:

- Tarkvaratehnika eriteemad (prof Ahto Kalja)
  Research group „Special topics of software engineering"
- Digitaalsüsteemide disain ja test (prof. Raimund Ubar)
  Design and test of digital systems

2. Arvutitehnika instituudi teadustöö kirjeldus
2.1. Research group „Special topics of software engineering"
2.1.1. Description of the research work

The research activities of the system software group includes the following topics: web based systems, e-Government, information systems and software development methods.

We are in large cooperation with researchers from EXCS (*Estonian eXcellence in Computer Science*).

During 2014, the research group has published 12 scientific papers, mainly in the conference proceedings.

2.1.2. Main research results in 2014

(1) We have investigated web system user interfaces and we have showed that the rate of user mistakes while exploiting graphical UI depends on whether advanced UI development techniques like prototyping techniques and user tests were applied during UI development or they were disregarded.

(2) Poorly working client-vendor relationship has been shown to be among the most common reasons for software project failures. One way to improve it is to set a common ground for communication: above all, by making sure that clients without software development background are knowledgeable of certain concepts and principles.

2.1.3 Five selected publications of the year 2014

1. Marenkov, Jevgeni; Robal, Tarmo; Kalja, Ahto (2014). A study on user click behaviour for WIS user interface improvements. Haav, Hele-Mai; Kalja, Ahto; Robal, Tarmo (Toim.). Databases and Information Systems VIII : Selected Papers from the Eleventh International Baltic Conference, Baltic DB&IS 2014 (173 - 186). Amsterdam: IOS Press

2. Ojastu, Deniss; Robal, Tarmo; Kalja, Ahto (2014). Expectations of software development practitioners for non-technical clients. Haav, Hele-Mai; Kalja, Ahto; Robal, Tarmo (Toim.). Databases and Information Systems VIII : Selected Papers from the Eleventh International Baltic Conference, Baltic DB&IS 2014 (317 - 330). Amsterdam: IOS Press

3. Haav, Hele-Mai; Kalja, Ahto; Robal, Tarmo (Eds.) (2014). Databases and Information Systems VIII : Selected papers from the Eleventh International Baltic Conference, Baltic DB&IS 2014. Amsterdam: IOS Press

4. Haav, Hele-Mai; Kalja, Ahto; Robal, Tarmo (2014). Preface. In: Databases and Information Systems VIII : Selected papers from the Eleventh International Baltic Conference, Baltic DB&IS 2014: (Toim.) Haav, Hele-Mai; Kalja, Ahto; Robal, Tarmo. Tallinn: Tallinn University of Technology Press, 2014, v.

5. Haav, Hele-Mai; Kalja, Ahto; Robal, Tarmo, eds. (2014). Databases and Information Systems : Proceedings of the 11th International Baltic Conference, Baltic DB&IS 2014, Tallinn, Estonia, 8-11 June 2014. Tallinn: Tallinn University of Technology Press

2.2. Research group "Digital design and test"
2.2.1. Description of the research work

During the last decade the evolution of electronic systems has made a major leap and introduced new design paradigms like network-on-chips, multi- and many-core systems, ubiquitous and massively parallel computing, resulting in increasing dependency of society on electronics and hence, in increasing role of the reliability, testability and dependability of modern electronic systems.

The research group is conducting investigations and development of new methods in the fields of design verification, test, and dependability of digital systems and their components in line with International Technology Roadmap for Semiconductors. The research is targeting important quality factors like time-to-market, power consumption and speed of systems in design, performance and quality in verification and test, as well as fault tolerance and dependability of systems during their life-time.

The most important R&D results have been achieved in specific topics of diagnostic modeling of systems, fault simulation, verification, automated design error diagnosis and debugging, test generation, high-performance embedded test instrumentation and system-wide fault management for failure resilience.

To support the research tasks, the department has EUROPRACTICE licenses for EDA tools from the major EDA vendors installed for experimental investigations. In addition, several in-house developed and open-source research frameworks are available. The department has testers for boards and innovative instrument equipment developed by spin-off Testonica Lab in a close cooperation with department.

During the last three years, 9 PhD students have defended their theses. During the last 15 years the group has participated in 12 EU-level collaborative research projects that have provided relevant topics for PhD thesis projects. Currently the research group is involved in the FP7 project BASTION, coordinated by spin-off Testonica Lab, and will coordinate the new H2020 project IMMORTAL which will start in the beginning of 2015.

The group is the leading partner of the Estonian research excellence centre CEBE which has the mission to improve the quality of life through technological innovations. The other two partners are Thomas Johann Seebeck Department of Electronics and Technomedicum. The research results of CEBE are related to the fields of design and test of dependable embedded systems, biosignal processing, semiconductor technology and biomedical engineering including applications and commercial products.

During 2014, the research group has published 41 peer-reviewed papers in the reputed journals (5 papers) and conferences (36 papers).

2.2.2. Main research results in 2014

1. A new theory has been developed for diagnostic modeling of digital systems with high- and low level decision diagrams (DD). In this field of research, **a new model of shared SSBDD (S3BDD) was developed which allowed to achieve several important practical results**: (a) to reduce the complexity of the previous BDD models, (b) to speed up simulation for both combinational and sequential circuits, and (c) to improve the known methods of fault collapsing both, in speed-up, and in the number of collapsed faults. Based on the new High-Level Decision Diagrams (HLDD) for modeling register transfer level systems, an efficient automated test program synthesis for testing of microprocessors was developed, which allowed to increase the fault coverage compared to

the known methods. The research results in this field have been published in one journal, and in three conference papers.

2. A new method was developed for simulating of transition delay faults (TDF) at different fault propagation conditions. The main idea of the method is to extend the TDF model, traditionally considered as a class of robustly tested delay faults, to a broader class of TDFs with four different detection conditions. A novel sequential 7-valued algebra was developed for TDF reasoning. The new method allows higher accuracy of transition delay fault coverage calculation compared to the known methods. The research results in delay fault testing have been published in two conference papers, including [4], and submitted for journal publication.

3. A novel very fast fault simulation method was developed, based on exact critical path reasoning in digital circuits. The method exploits two types of parallelism: bit-level parallelism for multiple pattern reasoning, algorithmic level parallelism for distribution of the reasoning process between different cores in a multi-core processor environment. To increase the speed and accuracy of fault simulation, compared with previous methods, in addition, a mixed level fault reasoning approach was developed. The method has been successfully approbated in evaluation of functional testing quality of signal processing systems. The main ideas of the method have been published in two conference papers, and accepted as a journal paper.

4. New methods and algorithms for biomedical signal acquisition and processing. The current approach is based on wireless measurement of pulse waves and on efficient low-power signal processing solution that can be used in wearable devices. The long-term objective of this work is to use the respiration signal together with heart rate and blood oxygen saturation level (SpO2), that are extracted from the pulse wave, for sleep apnea detection and screening purposes. Additionally the approach is going to be used for early detection of the atherosclerosis and possibly for other diagnostic methods that are based on pulse wave measurements.

5. A new method for generating rejuvenation sequences for CMOS Integrated Circuits using evolutionary algorithms was developed. The method addresses reversing the negative bias temperature instability aging effects by carefully engineered test stimuli. The work was carried out in cooperation with the researchers of Politecnico di Torino, Italy.

6. A new methodology for abstracting register-transfer level descriptions up to electronic system-level was developed. The methodology is based on a novel loose modeling concept. This work is part of the PhD thesis of S. A. Syed, a PhD student from the research group.

7. Development of a hardware-assertion based functional test method for routing engines in a NoC router. This is part of ongoing investigations related to functional on-line test of NoC communication infrastructures without application interruption/interference.

8. Development of coarse grained reconfigurable architectures targeting massive parallel signal processing algorithms. This work is done in cooperation with Royal Institute of Technology (Sweden) and Turku University (Finland).

9. We have investigated the possibilities to improve scalability and dependability of future Network-on-Chip (NoC)-based Multiprocessor System-on-Chip (MPSoC) Platforms. Considering the Through-Silicon-Vias (TSVs) as enabling technology for MPSoC, we have developed in cooperation with TU Darmstadt novel methods for adaptive routing in 3D chip-stacked NoC architectures, allowing a scalable density of vertical TSV connections. Furthermore we have developed a novel NoC dependability service layer "NoCDepend" (based on the Built-In Self-Test generated system health map) of a NoC, which provides fault tolerance with respect to any amount of defective communication links in a NoC and can be combined with any minimal or non-minimal deadlock-free

routing algorithm. This dependability method will be the basis for research in mixed-criticality application deployment and dynamic partitioning of NoCs.

2.2.3. Five selected publications of the year 2014

1. Jenihhin, Maksim; Tšepurov, Anton; Tihhomirov, Valentin; Hantson, Hanno; Raik, Jaan; Ubar, Raimund; Bartsch, Günter; Meza Escobar, Jorge Hernan; Wuttke, Heinz-Dietrich (2014). Automated Bug Localization in Processor Designs. IEEE Design & Test of Computers, 1, 83 - 92.
2. Jafri, S.M.A.H.; Tajammul, M.A.; Ellervee, P.; Hemani, A.; Paul, K.; Tenhunen, H.; Plosila, J. (2014). Morphable Compression Architecture for Efficient Configuration in CGRAs. The 17th Euromicro Conference on Digital System Design (DSD 2014), Verona, Italy, Aug. 2014, 1 - 8.
3. Jantsch, Axel; Tammemäe, Kalle (2014). A Framework of Awareness for Artificial Subjects. International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS 2014), New Dehli, October 12-17, 2014.
4. Leier, M.; Jervan, G.; Stork, W. (2014). Respiration Signal Extraction From Photoplethysmogram Using Pulse Wave Amplitude Variation. The 2014 IEEE International Conference on Communications (ICC), Sydney, Australia, June 10-14, 2014. IEEE, 2014, 3541 - 3546.
5. Tsertov, Anton; Devadze, Sergei; Jutman, Artur; Jasnetski, Artjom. "In-System Programming of Non-Volatile Memories on Microprocessor-centric Boards", in Int. Journal of Microelectronics and Computer Science IJMCS, Vol.5, No.1, 2014, pp. 25-34.

The criterion of paper selection was to present most of the teams of the research lab by their contributions. The full list of publications of the lab includes 41 papers.

3. Loetelu struktuuriüksuse töötajate rahvusvahelistest tunnustustest

1. Ahto Kalja - valiti Läti Ülikooli audoktoriks, 27.9.2014
2. J. Raik on valitud rahvusvahelise tippkonverentsi VLSI-SOC – 2016 esimeheks.
3. Maksim Jenihhin - Boriss Tamme stipendiumikonkursi laureaat
4. Raimund Ubar – Eesti Teaduste Akadeemia Nikolai Alumäe medal
5. Kutsutud plenaarettekanded konverentsidele
   - R.Ubar. Digital Test with Low- and High Level Decision Diagrams **Invited talk** at the workshop "Digital System Technology: Education, Research, and Industrial Aspects", Tehran, Iran, February 6-10, 2014.
   - R.Ubar. Fault Effect Reasoning in Digital Systems by Topological View on Low- and High-level Decision Diagrams - **Keynote talk** at the conf. "Computer Aided Technologies in Applied Mathematics". Tomsk, Russia, June 10-12, 2014.

4. Loetelu struktuuriüksuse töötajatest, kes on välisakadeemiate või muude oluliste T&A- ga seotud välisorganisatsioonide liikmed

1. G. Jervan ja K.Tammemäe on IEEE vanemliikmed
2. R. Ubar on IEEE Computer Science Golden Core liige ja Harkovi Rahvusliku Raadiotehnika Ülikooli auprofessor
3. A.Jutman, G. Jervan ja R.Ubar on Euroopa Insenerihariduse Assotsiatsiooni EAEEIE Nõukogu liikmed
4. G. Jervan ja R.Ubar on Ülemaailmse Testi Tehnoloogia Tehn. komitee TTTC liikmed
5. G. Jervan ja R.Ubar on Euroopa Testi Tehnoloogia Tehn. komitee ETTTC liikmed
6. Ahto Kalja - PICMET15 (USA) – riikide esinduskomitee liige, *Acta Universitatis Latviensis* seeria *Informatics* toimetuse liige

5. Aruandeaastal saadud T&A-ga seotud tunnustused (va punktis 3.2.3 toodud tunnustused), ülevaade teaduskorralduslikust tegevusest, teadlasmobiilsusest ning hinnang oma teadustulemustele.

1. Tunnustused:
   Ahto Kalja sai Eesti Vabariigi Valgetähe IV klassi teenetemärgi, 24.02.2014
2. 2014. a. lisandunud uued projektid:
   - CEBE teadlaste koordineeritav EL Horizon 2020 uurimisprojekt IMMORTAL (2015-2018), koordinaator J. Raik.
   - IUT 19-01. Usaldusväärsed mitmetuumalised arvutisüsteemid (20014 - 2019, koordinaator J.Raik)
   - On esitatud taotlused kolmele uue europrojekti saamiseks: Horizon 2020 Marie Skłodowska-Curie Innovative Training Network (ITN) RESCUE (üldkoordinaator M. Jenihhin), Horizon 2020 Marie Skłodowska-Curie Innovative Training Network (ITN) TRICOT (koordinaator J. Raik) ja Horizon 2020; Call: H2020-SEAC-2014-1, RIA, Projekt JASMIN (koordinaator Th.Hollstein)
3. Teaduskorralduslik tegevus
   - J.Raik on europrojekti EL Horizon 2020 „IMMORTAL „ (2015-2018) üldkoordinaator
   - A.Jutman on europrojekti FP7-ICT-2013-11 STREP „BASTION" (2014-2016) üldkoordinaator
   - G.Jervan oli konverentsi EWME 2014 üldjuht ning on EWME konverentside juhtkomitee liige
   - J. Raik on valitud konverentsi VLSI-SOC-2016 esimeheks
   - J. Raik oli konverentsi "Design and Diagnostics in Electronic Circuit and Systems" DDECS'2014 programmikomitee juht
   - J. Raik juhtis IEEE TTTC Edward McCluskey parima nanoelektroonika testimise teemalise doktoritööde konkurssi (Paderborn, Saksamaa)
   - M. Jenihhin oli konverentsi DATE Friday Workshop "MEDIAN 2015" programmikommitee juht
   - M. Jenihhin on konverentsi LATW Publication Chair ja R.Ubar LATW East-Europe Liaison
   - P. Ellervee on konverentsi „Baltic Electronic Conference" juhtkomitee ase-esimees
   - P. Ellervee oli konverentsi „International Symposium on System-on-Chip 2014" programmikomitee kaasjuht
   - R.Ubar oli konverentsi "East-West Design-and-Test Symposiumi" EWDTS'2014 aseesimees.
   - Th.Hollstein oli konverentsi „Smart SysTech 2014" juhtkomitee esimees
   - Korraldati kaks rahvusvahelist suvekooli BELAS-2 ja BELAS-3. Suvekoolide juhtkomitee esimees: M. Jenihhin.
   - R. Ubar on Eesti TA uurija-professorite valimiskomisjoni liige
   - G. Jervan on Euroopa Komisjoni poolt rahastatud projektide lõpphindaja ning FP7 projekt Secure-R2I väline ekspert.
   - P.Ellervee, Th. Hollstein, G.Jervan, M.Jenihhin, A.Jutman, J.Raik, K.Tammemäe, R.Ubar on mitmete konverentside juht- ja programmikomiteede liikmed
   - Viidi läbi Tippkeskuse CEBE konverents "Tarvilikud tehnikad tervikliku e-Tervise toeks" 9. okt. Tallinnas Meriton Grand hotellis.

- Ahto Kalja – korralduskomitee peaesimees ja Tarmo Robal – programmkomitee kaasesimees korraldasid 8-11 juuni 2014 Tallinnas teaduskonverentsi: 11th International Baltic Conference , Baltic DB&IS 2014

4. Teadlasmobiilsus:
   - Loengutega välismaal esinesid: A.Jutman (TU Darmstadt, TU Ilmenau, Samaara Riiklik Avio-Kosmose Ülikool), R.Ubar (TU Darmstadt, Samaara Riiklik Avio-Kosmose Ülikool), Maksim Jenihhin (videoloeng Hamm-Lippstadt'i Kõrgkoolis Saksamaal)
   - Doktoriväitekirju oponeerisid: P.Ellervee Soomes (Turu Ülikool) ja Taanis (Taani Tehnikaülikool), J.Raik ja R.Ubar Saksamaal (Brandenburgi Tehnikaülikool), Th.Hollstein Saksamaal (TH Darmstadt)