Thomas Johann Seebecki elektroonikainstituudi 2021. aasta teadus- ja arendustegevuse aruanne

2021. aasta edulood

Suurim edulugu kogu instituudi lõikes on seotud doktoriväitekirjade kaitsmisega: kõikide uurimisrühmade panus oli võrdne, iga rühma poolt kaks edukalt doktoriõpingud lõpetanud doktoranti. 2021. aastal kaitsesid oma väitekirja R. Khan, A. Tart, K. Pesti, R. Ehrminger, H. Rashid, M.H. Ziko.

2021. aastal saavutasid instituudi uurimisrühmad silmapaistvaid tulemusi uute uurimisprojektide ettevalmistamisel:

1. Mõõteelektroonika uurimisrühma poolt ette valmistatud projekt PRG 1483 "Innovatiivne impedantsspektroskoopia: lahendused ja rakendused" pälvis rahastuse aastateks 2022-2026.

2. Kommunikatsioonisüsteemide uurimisrühma poolt ette valmistatud projektitaotlus 5G-TIMBER (Secure 5G-Enabled Twin Transition for Europe's TIMBER Industry Sector), esitatud vastavalt projektikutsele HORIZON-CL4-2021-TWIN-TRANSITION-01, pälvis rahastuse 2022. aasta suvest kuni 2025. aasta suveni. Väärib märkimist, et antud projekti koostas ja kannab edaspidi koordinaatori vastutust kommunikatsioonisüsteemide uurimisrühm. Projektis osaleb 16 partnerit, sh mitmed Eesti tööstusettevõtted.

2021 success stories

The greatest success story on a department level is related to very successful defenses of doctoral theses: all research groups have equally contributed to supporting doctoral students to prepare their thesis – two students per group. In 2021, the following PhD students have successfully defended their dissertation: R. Khan, A. Tart, K. Pesti, R. Ehrminger, H. Rashid, M.H. Ziko.

In 2021, the research groups of our department have been very successful when it comes to new project preparation:

1. Measurement Electronics Research Group has successfully prepared PRG 1843 „Innovative impedance spectroscopy: solutions and applications” project application. The project has received financing for a period of 2022-2026.

2. Communication Systems Research Group has prepared 5G-TIMBER (Secure 5G-Enabled Twin Transition for Europe's TIMBER Industry Sector) project application, submitted to HORIZON-CL4-2021-TWIN-TRANSITION-01. This project has received financing for a period of mid- 2022 to mid-2025. Our research group shall be the coordinator of the project that involves 16 partners, including several Estonian industrial companies.

1. Struktuuriüksuse struktuur 2021. a

Thomas Johann Seebecki elektroonikainstituut (edaspidi TJS elektroonikainstituut).
Thomas Johann Seebeck Department of Electronics (hereinafter referred to as the TJS Department of Electronics).
Laur Lemendik, direktor, laur.lemendik@taltech.ee, +372 620 2151.

Instituudi üksused ja uurimisrühmad on:

- elektroonika ja sidetehnika õppekeskus, õppekeskuse juht Andres Eek, andres.eek@taltech.ee;
- kognitroonika teaduslabor, labori ja uurimisrühma juht kaasprofessor Yannick Le Moullec, yannick.lemoullec@taltech.ee;
- mõõteelektroonika uurimisrühm, uurimisrühma juht prof. Olev Märtens, olev.martens@taltech.ee;
- kommunikatsioonisüsteemide uurimisrühm, uurimisrühma juht prof. Muhammad Mahtab Alam, muhammad.alam@taltech.ee.

Units and research groups inside of the department are:

- Study Centre for Electronics and Communicative Technologies, head of the study centre Andres Eek, andres.eek@taltech.ee;
- Research Laboratory for Cognitronics, head of the laboratory and research group Associate Prof. Yannick Le Moullec, yannick.lemoullec@taltech.ee;
- Measurement Electronics Research Group, head of the research group Prof. Olev Märtens, olev.martens@taltech.ee;
- Communication Systems Research Group, head of the research group Prof. Muhammad Mahtab Alam, muhammad.alam@taltech.ee.

2. Teadus- ja arendustegevuse ülevaade uurimisrühmade lõikes

2.1 Mõõteelektroonika uurimisrühm

Uurimisrühma juht: Prof. Olev Märtens, olev.martens@taltech.ee, tel. 620 2167

Uurimisrühma liikmed:

Paul Annus, vanemteadur
Mart Min, teadur, emeriitprofessor
Andrei Krivošei, vanemteadur
Raul Land, vanemteadur
Hip Kõiv, doktorant, insener
Ksenija Pesti, doktorant
Eiko Priidel, doktorant
Robin Benjamin Ehrminger, doktorant
Anar Abdullayev, doktorant-nooremteadur

VÕTMESÕNAD: impedants-spektroskoopia, impedants-tomograafia, pöörisvool, real-aja, mõõtmine, mõõteriistad.

Uurimisrühma teadus- ja arendustegevus on suunatud elektrilise, peamiselt impedants-spektroskoopia (kuid mitte ainult) mõõtmislahendustele. See hõlmab vastavate instrumentide, signaalide ja signaalitöötluse arendamist ja uurimist erinevate rakenduste jaoks (mh testiks ja diagnostikaks, nt bio-, tervise- ja meditsiinitehnoloogiates, mikrofluidikas, metalli- ja elektroonikatööstustes ja mujal).

Uurimisrühma peamised tulemused 2021. aastal.

- Prof. Mart Min pälvis Tallinna ettevõtlusauhinna 2021 rakendusuuringu eest "Pulse wave and breathing curve sensor" (uurimisprojekti juht).

- Uurimistöö tulemusena esitati kaks impedantsimõõtmistega seotud **patenditaotlust:**
    - Eesti patendi taotlus: Mart Min, Jaan Ojarand, Eiko Priidel, Raul Land, Paul Annus, Olev Märtens; „A method and apparatus for determining physiological parameters of a body organ within a convex shape body parts;" Priority number: P202100015; Priority date: 17.05.2021;
    - Ameerika Ühendriikide patendi taotlus: US2021190841 (A1): Leiutaja(d): Paul Annus, Raul Land, Mart Min, Olev Märtens, Marek Rist, Eiko Priidel. „Device and method for measuring complex transfer of an object"

- Valitud publikatsioonid:
    - Pesti, K.; Metshein, M.; Annus, P.; Kõiv, H.; Min, M. (2021). Electrode Placement Strategies for the Measurement of Radial Artery Bioimpedance: Simulations and Experiments. IEEE Transactions on Instrumentation and Measurement, 70, 1−10;
    - Laasfeld, Tõnis; Ehrminger, Robin; Tahk, Maris-Johanna; Kõlvart, Karl Rene; Veiksina, Santa; Min, Mart; Kopanchuk, Sergei; Rinken, Ago (2021). Budded baculoviruses as a receptor display system to quantify ligand binding with TIRF microscopy. Nanoscale, 13, 2436−2447.

Uurimisrühma seotus TalTechi AAK prioriteetse suunaga:

- Targad ja energiatõhusad keskkonnad;

- Tulevikku vaatav riigivalitsemine.

Uurimisrühma tegevusega seotud teadusvaldkond:

- 2. Tehnika ja tehnoloogia ->2.2 Elektrotehnika, Elektroonika, infotehnika
- T170 Elektroonika (CERCS)
- T115 Meditsiinitehnika (CERCS)
- T121 Signaalitöötlus (CERCS)

Olulisemad projektid:

- MOBERA20 "Event Driven Artificial Intelligence Hardware for Biomedical Sensors (1.12.2019−31.10.2022)", Olev Märtens et al;
- LIEEE20036 "Collaboration Agreement: Non-Invasive Measurement of the Cardiovascular System in a Clinical Environment (9.04.2020−31.03.2022)", Mart Min et al;
- MINH21092 „Development of flexible labs for courses related to electronic measurements“ (1.11.2021−31.08.2022)", O. Märtens et al.

Info uurimisrühma rakendusliku väljundiga teadus- ja arendustegevuse kohta:

- AR21033 "Kõrgkooli õpik (eesti keeles) “Elektroonilised mõõtmised inseneerias” (15.05.2021−30.04.2022)", O. Märtens, TTU Raamatukogu.

2.2 Measurement Electronics Research Group

Head of the research group: Prof. Olev Märtens, olev.martens@taltech.ee, tel. 620 2167

Members of the research group:

Paul Annus, sen. researcher
Mart Min, researcher, prof. emeritus
Andrei Krivošei, sen. researcher
Raul Land, sen. researcher
Hip Kõiv, doctoral student, engineer
Ksenija Pesti, doctoral student
Eiko Priidel, doctoral student
Robin Benjamin Ehrminger, doctoral student
Anar Abdullayev, doctoral student, early stage researcher

KEYWORDS: impedance spectroscopy, impedance tomography, eddy current, real-time, measurement, instrumentation.

The group performs R&D of electrical mostly (but not limited) impedance spectroscopy measurement solutions. This covers the developing and investigation of related instrumentation, signals and signal processing for several applications (including test and diagnostics e.g. in bio-, healthcare, medical and microfluidics areas, for metal, electronics and other industries).

The research group has accomplished the following results in 2020.

- 2021, Mart Min, Tallinn City Entrepreneurship Award 2021 for applied research "Pulse wave and breathing curve sensor" (research leader).

- Based on the results of the research, two impedance-measurement related **patent applications** were submitted:
    - Estonian application: Authors: Mart Min, Jaan Ojarand, Eiko Priidel, Raul Land, Paul Annus, Olev Märtens; Invention: “A method and apparatus for determining physiological parameters of a body organ within a convex shape body parts”; Priority number: P202100015; Priority date: 17.05.2021;
    - US application US2021190841 (A1) : Inventor(s): Paul Annus, Raul Land, Mart Min, Olev Märtens, Marek Rist, Eiko Priidel. „Device and method for measuring complex transfer of an object”.

- Selected publications:
    - Pesti, K.; Metshein, M.; Annus, P.; Kõiv, H.; Min, M. (2021). Electrode Placement Strategies for the Measurement of Radial Artery Bioimpedance: Simulations and Experiments. IEEE Transactions on Instrumentation and Measurement, 70, 1−10;
    - Laasfeld, Tõnis; Ehrminger, Robin; Tahk, Maris-Johanna; Kõlvart, Karl Rene; Veiksina, Santa; Min, Mart; Kopanchuk, Sergei; Rinken, Ago (2021). Budded baculoviruses as a receptor display system to quantify ligand binding with TIRF microscopy. Nanoscale, 13, 2436−2447.

Affiliation of the research team to the TalTech Academic Development Plan priority areas:

- Smart and energy efficient environments;
- Future governance.

Field of research activity of the research group - up to two sub-fields based on the Frascati Manual's classification of scientific fields and disciplines:

- 2. Engineering and technology ->2.2 Electrical engineering, electronic engineering, information engineering
- T170 Electronics (CERCS)
- T115 Medical technology (CERCS)
- T121 Signal processing (CERCS)

Major research projects:

- MOBERA20 “Chist-ERA Project: JEDAI Event Driven Artificial Intelligence Hardware for Biomedical Sensors” (1.12.2019 -30.10.2022)”, Olev Märtens et al;
- LIEEE20036 "Collaboration Agreement: Non-Invasive Measurement of the Cardiovascular System in a Clinical Environment (9.04.2020−31.03.2022)", Mart Min et al;
- MINH21092 „Development of flexible labs for courses related to electronic measurements“ (1.11.2021−31.08.2022)", O. Märtens et al.

Information on applied research and development activities of the research group:

- AR21033 "University textbook (in Estonian) “Electronic measurements in engineering” (15.05.2021−30.04.2022)", O. Märtens, TTU Library.

2.3 Kognitroonika teaduslabor

Uurimisrühma juht: Kaasprofessor Yannick Le Moullec, yannick.lemoullec@taltech.ee, tel. 5844 6540

Uurimisrühma liikmed:

Muhammad Mahtab Alam, professor
Ants Koel, dotsent
Kaiser Pärnamets, lektor, doktorant
Sikandar Muhammad Zulqarnain Khan, doktorant
Udayan Sunil Patankar, doktorant
Haroon Rashid, doktorant
Mehadi Hasan Ziko, doktorant
Fariha Afrin, doktorant
Kanwal Ashraf, doktorant
Abdul Mujeeb, doktorant-nooremteadur

KEYWORDS: energiatõhusad asjade interneti platvormid, kiiplabor; pooljuhtelektroonika, nutikad multiskalaarsed pinnad.

Uurimisrühm arendab:

- mikro- ja sensortehnoloogiaid;
- madala võimsustarbega traadita side tehnoloogiaid;
- kognitiivseid meetodeid sensorandmete töötlemiseks ja tehisintellekti kasutamiseks.

Uurimisrühma peamised tulemused 2021. aastal.

- Valitud publikatsioonid:
    - Patankar, Udayan S.; Koel, Ants (2021). Review of Basic Classes of Dividers Based on Division Algorithm. IEEE Access, 9, 23035−23069. DOI: 10.1109/ACCESS.2021.3055735;
    - Khan, Sikandar; Alam, Muhammad Mahtab; Le Moullec, Yannick; Kuusik, Alar; Parand, Sven; Verikoukis, Christos (2021). An Empirical Modelling for the Baseline Energy Consumption of an NB-IoT Radio Transceiver. IEEE Internet of Things Journal. DOI: 10.1109/JIOT.2021.3072769;
    - Pärnamets, K.; Pardy, T.; Koel, A.; Rang, To.; Scheler, O.; Le Moullec, Y.; Afrin, F. (2021). Optical Detection Methods for High-Throughput Fluorescent Droplet Microflow Cytometry. Micromachines, 12. DOI: 10.3390/mi12030345
- Teaduspreemia:
    - Euromicro DSD 2021 Special Session Best Paper: Ashraf K.; Le Moullec, Y.; Pardy, T.; Rang, T. “Model-based System Architecture for Event-triggered Wireless Control of Bio-analytical Devices”, 24th Euromicro DSD.

Uurimisrühma seotus TalTechi AAK prioriteetse suunaga:

- Targad ja energiatõhusad keskkonnad

Uurimisrühma tegevusega seotud teadusvaldkond:

- 2.2 Elektrotehnika, Elektroonika, infotehnika (Frascati)
- T170 Elektroonika (CERCS)
- 2.10 Nanotehnoloogia (Frascati)

Olulisemad projektid:

- Interreg BSR "LUCIA: Läänemere piirkonna valgustus ” (01.01.2019 – 30.06.2021);
- PRG620 "CogniFlow-Cyte: Kognitiivne kiiplaborsüsteem automatiseeritud voolutsütomeetria tarbeks (1.01.2020−31.12.2024)" [Koostöö keemia ja biotehnoloogia instituudiga];
- PRG780 “CMS eksperimendi ettevalmistamine kõrge heledusega tööperioodil läbi triggeri uuenduste” (01.01.2020-31.12.2024) [Koostöö Keemilise ja Bioloogilise Füüsika Instituudiga].

2.4 Research Laboratory for Cognitronics

Head of the research group: Associate Prof. Yannick Le Moullec, yannick.lemoullec@taltech.ee, tel. 5844 6540

Members of the research group:

Muhammad Mahtab Alam, prof.
Ants Koel, associate prof.
Kaiser Pärnamets, lecturer, PhD student
Sikandar Muhammad Zulqarnain Khan, PhD student
Udayan Sunil Patankar, PhD student
Haroon Rashid, PhD student
Mehadi Hasan Ziko, PhD student
Fariha Afrin, PhD student
Kanwal Ashraf, PhD student
Abdul Mujeeb, early stage researcher, PhD student

KEYWORDS: energy-efficient IoT platforms, Lab-on-Chip; semiconductor electronics, smart multiscale surfaces.

The research group develops:

- methods and techniques for miniaturized actuators and sensor technologies;
- resource-constrained implementation of wireless technologies;
- transition methods for exploitation and implementation of sensors in data processing and artificial intelligence for decision-making and actuation.

The research group accomplished the following results in 2021.

- Selected publications:
  - Patankar, Udayan S.; Koel, Ants (2021). Review of Basic Classes of Dividers Based on Division Algorithm. IEEE Access, 9, 23035−23069. DOI: 10.1109/ACCESS.2021.3055735;
  - Khan, Sikandar; Alam, Muhammad Mahtab; Le Moullec, Yannick; Kuusik, Alar; Parand, Sven; Verikoukis, Christos (2021). An Empirical Modelling for the Baseline Energy Consumption of an NB-IoT Radio Transceiver. IEEE Internet of Things Journal. DOI: 10.1109/JIOT.2021.3072769;
  - Pärnamets, K.; Pardy, T.; Koel, A.; Rang, To.; Scheler, O.; Le Moullec, Y.; Afrin, F. (2021). Optical Detection Methods for High-Throughput Fluorescent Droplet Microflow Cytometry. Micromachines, 12. DOI: 10.3390/mi12030345.
- Award:

- Euromicro DSD 2021 Special Session Best Paper: Ashraf K.; Le Moullec, Y.; Pardy, T.; Rang, T. “Model-based System Architecture for Event-triggered Wireless Control of Bio-analytical Devices”, 24th Euromicro DSD.

Affiliation of the research team to the TalTech Academic Development Plan priority areas:

- Smart and energy efficient environments.

Field of research activity of the research group - up to two sub-fields based on the Frascati Manual's classification of scientific fields and disciplines:

- 2.2 Electrical engineering, electronic engineering, information engineering (Frascati)
- T170 Electronics (CERCS)
- 2.10 Nano-technology (Frascati)

Major research projects:

- Interreg BSR "LUCIA: Lighting the Baltic Sea Region” (01.01.2019 – 30.06.2021);
- PRG620 “CogniFlow-Cyte: Cognitronic Lab-on-a-Chip System for Highly-Automated Flow Cytometry” (01.01.2020 - 31.12.2024) [Collaboration with Dept. Chemistry and Biotechnology];
- PRG780 “Preparing the CMS experiment for high luminosity operations through trigger improvements ” (01.01.2020-31.12.2024) [Collaboration with National Institute of Chemical Physics and Biophysics].

2.5 Kommunikatsioonisüsteemide uurimisrühm

Uurimisrühma juht: Prof. Muhammad Mahtab Alam, muhammad.alam@taltech.ee, tel. 620 2164

Uurimisrühma liikmed:

Toomas Ruuben, vanemlektor
Alar Kuusik, vanemteadur
Julia Berdnikova, lektor
Ivo Müürsepp, vanemlektor
Eerik Lossmann, vanemlektor
Priit Roosipuu, sidelahenduste arendaja
Osama Mohamed Mostafa Elgarhy, järeldoktor-teadur
Dadmehr Rahbari, järeldoktor-teadur
Ali Masood, doktorant-nooremteadur
Rida Khan, doktorant
Collins Burton Mwakwata, doktorant
Taavi Laadung, tööstusdoktorant
Marika Kulmar, doktorant-nooremteadur
Harish Kumar Singh, doktorant-nooremteadur
Jakob Rostovski, doktorant-nooremteadur
Mihkel Tommingas, tööstusdoktorant
Aleksei Fjodorov, tööstusdoktorant

VÕTMESÕNAD: raadiovõrgu ressursside ja interferentsi haldus, masin-masin kommunikatsioon, madala võimsustarbega kommunikatsioonitehnoloogiad tervishoius, 5G (5. põlvkonna) ja 5G-järgne mobiilside, NBIoT (kitsaribaline asjade Internet), BAN.

Uurimisrühma teadus- ja arendustegevus on suunatud raadiovõrgu interferentsi haldamisele traadita sides: tehnikad ja algoritmid 5G raadioside võimaldamiseks; 5G testikeskkonna arendamine, mh suure arvu masinate vahelise lairiba-mobiilside teenused ja kõrge usaldusväärsuse ja lühikese latentsusajaga sideteenused ning digiühiskonna (tark tervishoid, tark linn, tööstus 4.0) vertikaalsete teenuste arendamine, sh ühenduvus, mobiilsus, lõppkasutajad.

Uurimisrühma peamised tulemused 2021. aastal.

- Edukas projekti LIEEE20118 teostamine, mille tulemusena Majandus- ja Kommunikatsiooniministeeriumi poolt saadeti tänukiri koostöö eest 5G mobiilside arendamisel Eestis ja eriti uuringu „5G teenuste kasutusjuhtude tuvastamine“ läbiviimisel.

- Panus rahvusvaheliste standardite arendamisse:
  - ETSI SmartBAN Standard TR 103 711 „Published“;
  - IEEE Green ICT EECH standard (par 1923), kinnitatud märtsis, 2021.

- Uurimistöö tulemusena saadi üks patent ja esitati üks patenditaotlus:
  - System and method for self-assessment of physical capabilities and condition changes; Owners: Tallinn University of Technology , Motionmon OÜ; Authors: Alar Kuusik, Katrin Gross-Paju, Muhammad Mahtab Alam; Priority number: US16/268134; Priority date: 5.02.2019. Kinnitatud;
  - Interference minimizing cooperative scheduler for orthogonal multiple access (OMA) and non-orthogonal multiple access (NOMA) wireless communications; Owners:

Tallinn University of Technology ; Authors: Muhammad Mahtab Alam, Collins Burton Mwakwata; Priority number: FR2103489; Priority date: 6.04.2021. Ülevaatamisel.

- Valitud publikatsioonid:
  - C. B. Mwakwata, O. Elgarhy, M. M. Alam, Y. Le Moullec, Sven Pärand, Konstantinos Trichias, Kostas Ramantas (2021). Cooperative Scheduler to Enhance Massive Connectivity in 5G and Beyond by Minimizing Interference in OMA and NOMA. IEEE Systems Journal. DOI: 10.1109/JSYST.2021.3114338;
  - D. Rahbari, M. M. Alam, Y. Le Moullec, M. Jenihhin (2021). Fast and Fair Computation Offloading Management in a Swarm of Drones Using a Rating-based Federated Learning Approach. IEEE Access, 9, 113832−113849. DOI: 10.1109/ACCESS.2021.3104117;
  - I. Müürsepp, M. Kulmar, O. Elghary, M. M. Alam, T. Chen, S. Horsmanheimo, J. Scholliers (2021). Performance Evaluation of 5G-NR Positioning Accuracy Using Time Difference of Arrival Method. IEEE International Mediterranean Conference on Communications and Networking, pp. 494-499, DOI: 10.1109/MeditCom49071.2021.9647652.

Uurimisrühma seotus TalTechi AAK prioriteetse suunaga:

- Targad keskkonnad (asjade internet, 5G-asjade internet, targad elektroonsed süsteemid);
- Ühiskonna digitaliseerimine (tervishoiutehnoloogiad).

Uurimisrühma tegevusega seotud teadusvaldkond:

- 2.2 Elektrotehnika, Elektroonika, infotehnika
- T170 Elektroonika (CERCS)
- T180 Telekommunikatsiooni tehnoloogia (CERCS)

Olulisemad projektid:

- VFP20045 H2020 5G-ROUTES: 5th Generation connected and automated mobility cross-border EU trials (2020-2023);
- VNT18039 NATO SPS Public Safety Communication in the Context of Terrorists Attacks (01.06.2018-01.05.2021);
- PRG424 "Tagasisidestatav andmevahetussüsteem kõrge reaktiivsusega abistava neuromuskulaarse stimulatsiooni võimaldamiseks (1.01.2019−31.12.2023)".

Info uurimisrühma rakendusliku väljundiga teadus- ja arendustegevuse kohta:

- LIEEE20118 – Majandus- ja Kommunikatsiooniministeeriumi poolt tellitud rakendusuuring koostöös ettevõttega Civitta Eesti AS 5G teenuste kasutuslugude kohta;
- LIEAE21107 – NATO Küberkaitsekeskuse (CCDCOE) poolt tellitud rakendusuuring 5G *Cellular Vehicle to Everything (C-V2X)* sideteenuste kohta.

2.6 Communication Systems Research Group of Thomas Johann Seebeck Department of Electronics

Head of the research group: Prof. Muhammad Mahtab Alam, muhammad.alam@taltech.ee,

tel. 620 2164

Members of the research group:

Toomas Ruuben, sen. lecturer
Alar Kuusik, sen. researcher
Julia Berdnikova, lecturer
Ivo Müürsepp, sen. lecturer
Eerik Lossmann, sen. lecturer
Priit Roosipuu, telecom solutions developer
Osama Mohamed Mostafa Elgarhy, post-doctoral researcher
Dadmehr Rahbari, post-doctoral researcher
Ali Masood, early stage researcher, doctoral student
Rida Khan, doctoral student
Collins Burton Mwakwata, doctoral student
Taavi Laadung, doctoral student (industrial PhD)
Marika Kulmar, early stage researcher, doctoral student
Harish Kumar Singh, early stage researcher, doctoral student
Jakob Rostovski, early stage researcher, doctoral student
Mihkel Tommingas, doctoral student (industrial PhD)
Aleksei Fjodorov, doctoral student (industrial PhD)

KEYWORDS: radio resource and interference management, device to device communications, low-power communication technologies for healthcare, 5G and Beyond, NB-IoT, BAN.

The group performs R&D of interference control in wireless communication: techniques and algorithms for enabling 5G new radio, but also development of 5G testbed including support to realize massive machine type communication enhanced mobile broadband services and ultra-reliable and low latency communication services and digitalization of society (i.e., smart healthcare, smart city, industrial automation 4.0) development of vertical applications and services including connectivity, mobility, end-user community.

The research group has accomplished the following results in 2021.

- Successful implementation of project LIEEE20118, followed by Letter of appreciation from the Ministry of Economic Affairs and Communications for cooperation in developing 5G mobile communications in Estonia and contributing to the study “Identification of 5G service use cases”, in particular.

- Contributions in International Standards:
    - ETSI SmartBAN Standard TR 103 711 „Published“;
    - IEEE Green ICT EECH standard (par 1923), kinnitatud märtsis, 2021.

- Based on the results of the research, one patent was approved and one patent application submitted:

- System and method for self-assessment of physical capabilities and condition changes; Owners: Tallinn University of Technology, Motionmon OÜ; Authors: Alar Kuusik, Katrin Gross-Paju, Muhammad Mahtab Alam; Priority number: US16/268134; Priority date: 5.02.2019., Accepted;
- Interference minimizing cooperative scheduler for orthogonal multiple access (OMA) and non-orthogonal multiple access (NOMA) wireless communications; Owners: Tallinn University of Technology; Authors: Muhammad Mahtab Alam, Collins Burton Mwakwata; Priority number: FR2103489; Priority date: 6.04.2021. Under Review.

- Selected publications:
  - C. B. Mwakwata, O. Elgarhy, M. M. Alam, Y. Le Moullec, Sven Pärand, Konstantinos Trichias, Kostas Ramantas (2021). Cooperative Scheduler to Enhance Massive Connectivity in 5G and Beyond by Minimizing Interference in OMA and NOMA. IEEE Systems Journal. DOI: 10.1109/JSYST.2021.3114338;
  - D. Rahbari, M. M. Alam, Y. Le Moullec, M. Jenihhin (2021). Fast and Fair Computation Offloading Management in a Swarm of Drones Using a Rating-based Federated Learning Approach. IEEE Access, 9, 113832−113849. DOI: 10.1109/ACCESS.2021.3104117;
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Affiliation of the research team to the TalTech Academic Development Plan priority areas:

- Smart environments (IoT, 5G-IoT, Smart Electronic Systems);
- Digital transformation of the society (Health technologies).

Field of research activity of the research group:

- 2.2 Electrical Engineering, electronics engineering, information engineering (Frascati)
- T180 Telecommunications technology (CERCS)
- T170 Electronics (CERCS)

Major research projects:

- VFP20045 H2020 5G-ROUTES: 5th Generation connected and automated mobility cross-border EU trials (2020-2023);
- VNT18039 NATO SPS Public Safety Communication in the Context of Terrorists Attacks (01.06.2018-01.05.2021);
- PRG424 ETAg Closed-loop communication system to support highly responsive neuromuscular assistive stimulation (01.01.2019-31.12.2023).

Information on applied research and development activities of the research group:

- LIEEE20118 Applied Research Agreement with Civitta Eesti AS for 5G services use case study ordered by the Ministry of Economic Affairs and Communications;
- LIEAE21107 – Applied Research Agreement with NATO CCDCOE about 5G Cellular Vehicle to Everything (C-V2X) communication services.