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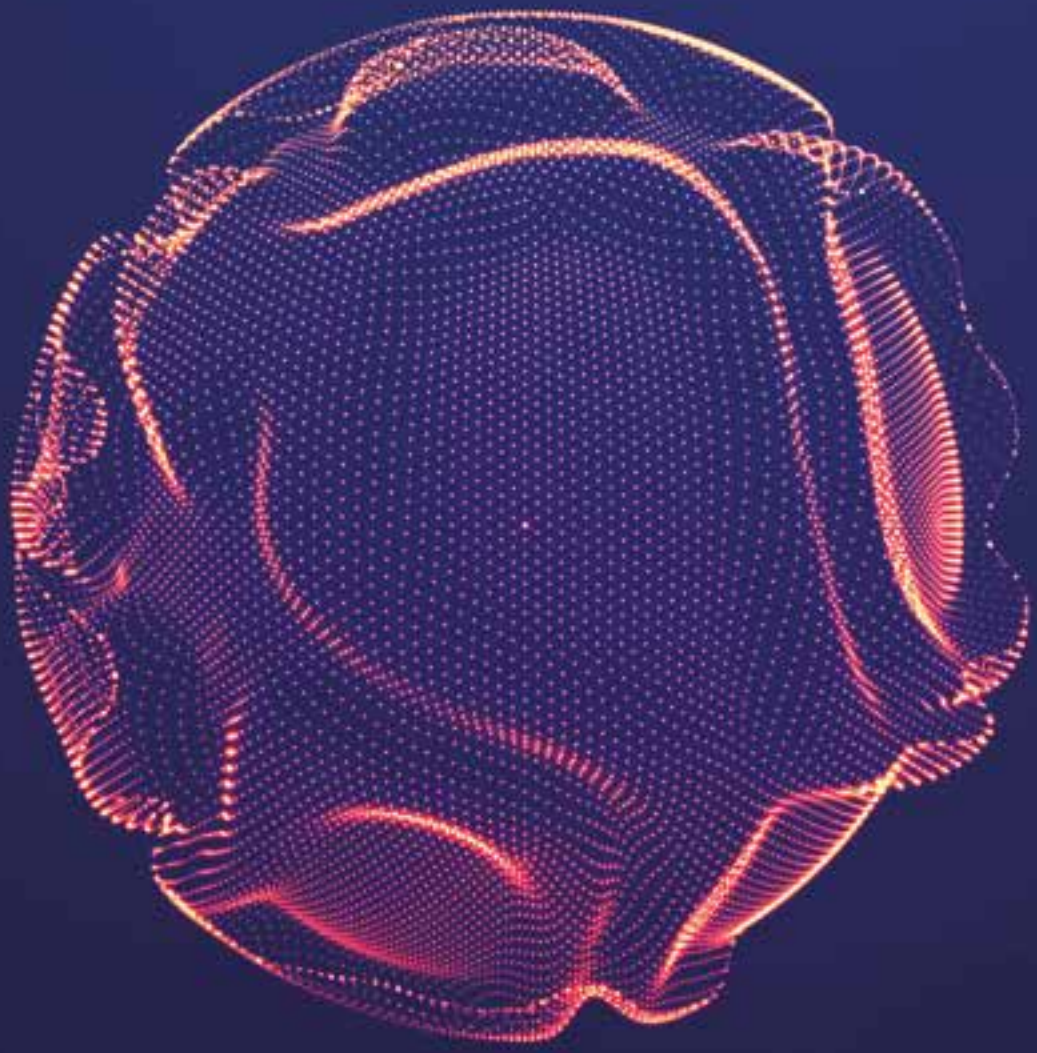

Growth engines of tomorrow:
The challenge of embedded Intelligence

ARTEMIS
Industry Association

Digitalisation,
Flexibility and Industry 4.0

FOREWORD

Dear participants in the ARTEMIS Community,

As announced in my foreword in the previous Magazine, which was issued in December last year, the European Commission, the European Parliament and the Council of the European Union entered into negotiations on Horizon Europe as the successor of the current framework programme Horizon 2020. The good news is that in March the negotiators reached a provisional political agreement, which was formally adopted by Parliament and Council in April. The bad news is that the budget has not yet been decided, as it will depend on the Multi-annual Financial Framework of the EU for the period 2021-2027, which will be negotiated in Autumn. Also synergies between Horizon Europe and other EU funding programmes still need to be negotiated, as well as possibilities for third countries to associate with Horizon Europe.

Nevertheless, the European Commission has meanwhile initiated the strategic planning process for the detailed implementation of Horizon Europe. In addition, preparations for the new generation of partnerships has begun; public consultations will open soon.

In any case, the landscape of partnerships will be streamlined: the number of partnerships will be reduced and there will only be three types: co-programmed (more or less comparable to the current contractual public-private Partnerships), co-funded partnerships with Member States (similar to the current joint programmes) and institutionalised partnerships (e.g. joint undertakings). The expectation is that ECSEL will be continued as a joint undertaking, whether under the name of ECSEL2, KDT (Key Digital Technology) or yet another name. The first calls should be out in first half of 2021.

The European Commission clearly indicated that in the successor of ECSEL relatively more attention should be given to software beyond embedded software, as the centre of gravity of the economic value of the complete value-chain of embedded intelligence is moving to the applications. Anticipating on that trend ARTEMIS-IA commissioned a study by Advancy, titled "Embedded Intelligence: Trend and Challenges". This report was launched on March 22 and got a positive appreciation from the European Commission and the Member States. You will find a summary of the key messages in this report by Saad Khaled (Advancy) and myself as presented at the recent ARTEMIS Technology Conference in Amsterdam on April16-17. The full report is downloadable from the website of ARTEMIS-IA.

In this Magazine you will find an impression of the ARTEMIS Technology Conference (ATC) and summaries of the presentations given by prof. Martin Törngren on "A new Era for CPS", by Klaus Beetz¬ on "Digitalisation, Flexibility and Industry 4.0", by Lucie Beaumel on "Seeing the bigger picture; the technology challenges of automotive", by Reiner John on "Autodrive", by Stefan Poledna on "Shaping the convergence of IT and OT", ¬by Elena Tsiporkova on "Knowledge versus data" and by Jeroen Voeten on "Digital Twinning".

Furthermore, you will find a report of the final event from the ENABLE-S3 project, with the technical content based on "Pursuit of simplicity", as explained by Michael Paulweber.

Finally, Jerker Delsing reports from the kick-off of the Arrowhead Tools projects on May 14.

I wish you an enjoyable read.

Jan Lohstroh
Secretary General ARTEMIS Industry Association

CONTENT

GROWTH ENGINES OF TOMORROW: THE CHALLENGE OF EMBEDDED INTELLIGENCE

by **JOSH GRINDROD**

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Embedded Intelligence is set to become an integral part of every value chain and a driving force in a new industrial revolution. As a result, Europe faces a dual challenge: the value in these chains is not only shifting downstream, away from current strengths, but also geographically – towards China, the US, Japan and South Korea. "There was a need to recalibrate ourselves," admits Jan Lohstroh, Secretary General of ARTEMIS-IA. The result is Embedded Intelligence: Trends and Challenges, a study *by independent consultant Advancy.*

CROSSING THE DIVIDES

This is not to say that ARTEMIS is doing poorly – quite the opposite. With over 200 members, the association enables continuous cross-industry collaboration on complex digital systems in multiple domains. "A very good example of cooperation between different areas," Jan notes, "is how products are taken, for instance, from automotive to healthcare. Our SRA [Strategic Research Agenda] is fully-integrated into the complete value chain of ECS-SRA, together with AENEAS and EPoSS, and is also the basis for the Multiannual Strategic Plan of ECSEL." In areas as diverse as smart mobility, energy and digital life, ARTEMIS is a key player in Europe.

By focusing on Embedded Intelligence, the aim is to maintain this position and play a major role in the revolution. "We concluded that there are six domains which are important for our community to work together to build Embedded Intelligence: Embedded & Cyber-Physical Systems, secure IoT & Systems of Systems, edge computing & Embedded Artificial Intelligence, Embedded High-Performance Computing, Systems of Systems integration platforms for digitalisation and Embedded Software technologies & software engineering tools. These are the areas that we will concentrate on in the coming years." On that note, Jan hands over to Advancy Principal Saad Khaled for a detailed outline of the study.

"Value is shifting drastically downstream. We will witness a tenfold increase in this Systems of Systems value."

THE NEW REVOLUTION

Saad doesn't beat around the bush. "We stand at a crossroads in the European Union, in regards to Cyber-Physical Systems, for a simple reason," he begins. "We have a willingness to achieve objectives of growth, empowering EU youth and addressing both responsibility and competitiveness. At the same time, we are facing major challenges in terms of finding growth engines and dealing with the complicated macroeconomic context." Saad cites three factors that bring about industrial revolutions: a new source of energy, a new transportation system and a new communications system. Steam engines, telegraphs, oil and mass media have all played these roles in years gone by. Saad: "Today, we have new sources of energy that are more renewable, the more mature communication internet that is intertwined with our everyday lives and this new, multimodal transportation network that is being deployed in various places across Europe and the world."

The notion of distribution is present in all of these systems. The current revolution is therefore unique in that it doesn't require a breakthrough in a specific technology, but rather a neural system over the top of many existing technologies. "Embedded Cyber-Physical Systems are paramount," Saad argues, "because they will be everywhere. They will have to be implemented in every system as bridges between the physical world and the software and cyberworld." Complexity arises as the physical world is heavily driven by products and ownership, whereas the cyberworld is based around ecosystems and scalability as sources of value. For Advancy, it was important to capture all of these elements in a six-step value chain for CPS, beginning with equipment and tools and extending all the way up to Systems of Systems. In the case of automotive, for instance, the first stage encompasses semiconductors and the sixth refers to traffic management in Smart Cities.

CHASING VALUE

Perhaps unsurprisingly, 75% of value is currently located in the first four steps – in other words, EUR 1.7 trillion lies in physical and electronic systems. A comparatively meagre EUR 500 billion is found at the Systems of Systems step. "We have still not witnessed the full potential of growth that is expected in those applications," explains Saad. "Value is shifting drastically downstream. We will witness a tenfold increase in this Systems of Systems value." Conversely, the value in the earlier steps will only manage to double between now and 2025, reducing it to a mere third of the sum total. "As an investor, if you had to invest in R&D projects, the return [on CPS] looks quite high and quite interesting." Then there's the geographical factor. Saad points to a graph showing the relative economic weight of China, the US and the EU. "We see that we're losing ground to China and the US in terms of GDP, but this is not news. What is less perceived today is that when you look at the amount of R&D that is spent on Chinese soil, US soil and European soil, we're also losing ground. The value in research is moving out of Europe." The trend is matched in the private sector, in which research investment notably also lags behind South Korea. There's no way to sugar-coat it. "In every type of measure, be it nominal absolute value, percentage of GDP or relative GDP, we are below our key competitors in terms of Cyber-Physical System investments," Saad adds. "We might run into trouble in the future with such a discrepancy."

DEFINING LEADERSHIP

On the other hand, there are strengths to fall back on. The EU is the historical leading force in smart transportation and has a strong position on energy, digital monitoring and edge computing. With such rapid technological developments underway, current successes are by no means a guarantee of future promise – but they are an important springboard. "Some battles, if they are not lost, are not the priority. So how do we take it from here?" asks Saad. "We believe that there should be five key objectives, pursued at a European level, to establish and guarantee the core applications in which we have leadership today. We can then prepare for the future and the upcoming competition."

1. Create jobs
2. Build leaders
3. Protect sovereignty
4. Prepare for convergence
5. Increase research efficiency and proximity to industry

"The first one is related to capturing the right skills. One of the key shortages today is software engineers and electronic engineers," Saad says. "Those jobs are being sought after by several companies while not being able to be filled. This is one key challenge where Europe has a role to play." As for building leaders, Advancy sees two distinct components: supporting European companies in building a successful ecosystem of applications and solutions and becoming global market leaders in transportation, energy, digital life and digital industry. The third objective, meanwhile, revolves around making sure that European sovereignty is developed and maintained on strategic technologies and components following several challenges, such as the case of NXP Semiconductors.

"The fourth recommendation is to prepare for convergence. We need to think outside of one single vertical, but in the convergence between verticals. The convergence between energy, communication and transportation needs to be addressed. We cannot think in silos anymore," warns Saad. Finally, closer links between research and applications will allow European industry to remain competitive, increase efficiency, attract investment and protect Intellectual Property. "Bring on more OEMs and Tier 1s into the Cyber-Physical Systems research in order to bring growth in the future."

PLAYING TO YOUR STRENGTHS

"We believe, given those growth figures, that Embedded and Cyber-Physical Systems are at the centre of Europe's future competitiveness and growth," says Saad. "Europe needs to increase its investments significantly. We need to have at least an equal footing on the right level of investments in hardware and software." With its focus on the six aforementioned domains, it's clear that the ARTEMIS community can play a key role in structuring Europe's R&D&I environment to capture the upcoming opportunities.

"I wouldn't say that the vision is grim, I'd say that it's a wake-up call. Yes, we are under a challenge, but we are starting from somewhere. As a consultant, I would tell you to start where you're good," Saad concludes. "Try not to be caught up on transportation, energy and digital industry. These are our strongholds as Europeans. It doesn't mean that we don't need to be active in the other areas, because sometimes they are relevant to our sovereignty, data privacy and value. The wake-up call remains the same."

DIGITALISATION, FLEXIBILITY AND INDUSTRY 4.0

TAKING THE MILK OUT THE COFFEE

Interview with **KLAUS BEETZ** *by* **JOSH GRINDROD**

When the newly elected Board member of Artemis-IA discusses Industry 4.0, his words hold weight and people listen to the newcomer. After all, Europe has been the driving force in industrial automation since Industry 1.0, the steam engine and the power loom. Building on the 'third wave' of electronics and IT, Industry 4.0 represents digitalisation. This, argues Klaus Beetz, offers Europe the opportunity to revolutionise the production chain and even the very way we live our lives. At the ARTEMIS Technology Conference 2019, he outlined the challenges and opportunities that digitalisation brings.

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THE WORLD OF OUR GRANDCHILDREN

"You know," Klaus begins, "European industrial leaders like Siemens and others have a long history and tradition in industrial automation, from the first days of industrialisation to the third revolution when software was first used for automation. So, it's a natural step for Europe to deliver digital means, processes, methodologies and tools for the Digital Economy of the 21st century." As much as 30% of Europe's GDP still depends directly on manufacturing, with more than two million companies currently active in this field. Over 90% of these are SMEs. Keeping up with the rapid developments in digital technologies and new concepts, such as blockchain and additive manufacturing, is almost impossible for most of them. "We have to help them with their transformation using digital technology," says Klaus, "so that Europe, also in the future, will be the leading continent when it comes to manufacturing."

For Europe, the business-to-consumer ship has sailed, with the US and China having established complete dominance. The business-to-business domain, on the other hand, is a comparatively recent development, in which the opportunity to become a key player still exists. Klaus does acknowledge, however, that the push for automation worries some. "There is a huge debate about if automation and robots will cause work to be diminished and if we'll have to occupy the people with, I don't know, Netflix and a European Super Soccer League. I think that this will not be the right solution for keeping our European society stable and not causing a bloody revolution, to say it a little bit dramatically," he laughs.

Delving into history, Klaus cites John Maynard Keynes and his 1930 essay *Economic Possibilities for our Grandchildren* as one outlook on an automated future. This, Klaus points out, was written in the wake of the worst economic depression in modern history. "There, in this short essay, he already stated that if we deploy technologies in the right way, our grandchildren will live in welfare and abundance. They will work, he said, three hours a day and fifteen hours a week. Otherwise, they will have time for their families, for their social lives, to engage in society. This is still a valid vision," he states optimistically.

The younger generation has a completely different mentality on a number of things. They have grown up with streaming and are used to doing things on-demand, not waiting until 8 o'clock when the news is on the television."

"Maybe our attitude to work has also to change. If we go back to old Rome, work was done by the slaves, work had very negative connotations. Then there was Benedict, founder of the Benedictine monks, who said "*ora et labora!*" He defined work as something good with a very positive meaning. Go to the sixteenth century, with evangelists from the Netherlands, from Switzerland. For them, work was the only meaning in the world! Now we have to go back and find an attitude towards work where we say, 'okay, we have to work, work is necessary, but it is not the ultimate goal of a human being just to work'. Maybe people will understand that there are other domains in life and maybe three hours per day and fifteen hours per week would be sufficient for them."

THE YOUTH EFFECT

One area in which attitudes are already changing is the trend for customers to pay for OPEX instead of CAPEX – to buy mechanical energy instead of motors and drives. Instead of a one-time payment to own a product, many customers would rather pay a monthly fee for availability and monitoring, with companies like Siemens taking care of maintenance and services. Klaus chalks this up to the environment in which today's younger generation has grown up.

"If I look at my daughter, I had to convince her to go for a driving license," he explains. "She doesn't need a car that is parked on the street three or four days per week when she only needs it for one. The younger generation has a completely different mentality on a number of things. They have grown up with streaming and are used to doing things on-demand, not waiting until 8 o'clock when the news is on the television."

On-demand, by nature, involves a degree of personalisation; personalisation in manufacturing requires flexibility. Today's BMWs, for instance, are each almost unique due to the enormous range of customisable parameters. The pharmaceutical field, too, is orienting itself more towards individualised pills in place of mass production. This presents another challenge: how can we continue to digitalise and automate factories while guaranteeing the necessary flexibility and personalisation that customers are looking for? How can we circumnavigate both a lack of transparency in operational machine data and limits in machine performance?

One example of a European solution has been MindSphere from Siemens, part of the Siemens Digital Enterprise Suite. This cloud-based, open operating system for the Internet of Things (IoT) collects and analyses operational data from sensors in real-time. This data is made accessible through MindApps – digital applications created by OEMs, end customers, partners and Siemens itself – and can be used to optimise products and processes at every stage of the manufacturing value chain. MindSphere's MindConnect element, meanwhile, offers open standards for connectivity with which users can obtain entire sets of machine, plant or fleet data regardless of their differing manufacturers. This opens to the door to digital twins in the smart factories of the future.

DIGITAL TRIPLETS

"When we talk about digital twins," Klaus notes, "we have to talk about three kinds of digital twins. The first is the digital twin of the product, that you have all information about your product available. The second is the production twin – to have, in the virtual world, all the knowledge of how a product is produced. Then we have the third twin, which is the performance twin, the twin of usage of the product at the customer side."

Currently, digital twins focus on the first two of these, but we have to unite all three to create systems that configure their own parameters in real-time. There's a long way to go, but test projects with Maserati and Bausch + Ströbele have achieved notable successes; the former has seen a 30% shorter development time and three times as many cars produced, while the latter has managed a 30% shorter engineering time through consistent, end-to-end digitalisation. Obvious benefits of digital twins include validation of a plant's productivity and the elimination of bottlenecks, but Klaus hones in on visualisation as one interesting aspect.

"This is really not just a simulation with nice animations," he states, referring to the digital twin of an assembly line. "There are mathematical models behind it that calculate the behaviour of different parts of your production line. In the virtual world, you can undo and redo, you can destroy messages and send them again, a lot of stuff. In the real world, you can't get the milk out of your coffee after you've put it in. The digital twin is an option to do as much as possible in the virtual world. Once you are sure that this is what you need, you can go down to the shop floor and configure your production line and start production. This will save a lot of time and money."

As for the way forward, Klaus sees a convergence of Smart Products (the digitalisation of pre-existing factories), Smart Factories/Plants (the digitalisation and integration of complete value chains) and Smart Services (innovative, digital business models). "In the future, we will have massive computer power, not only in the cloud and specific buildings but at the Edge, at the device. This offers new possibilities. What to do in the background? What to do the Edge? How much intelligence to put at the Edge and how much in the cloud? All this has to be embedded in a cyber-security concept because everything is equipped with computer power. If everything is connected with everything, there is the threat that everything can be attacked by hackers." The Siemens Charter of Trust, which calls for binding rules and standards in cybersecurity, may provide a framework for this.

A UNIFIED PATH

Klaus has recently been appointed a member of the ARTEMIS Steering Board. Closing on a positive note, he mentions the important role that ARTEMIS can play in what he's discussed. "We can build pilots and make proposals to the standardisation organisations. This is what we need from an industrial perspective, that the equipment from different suppliers can work together smoothly." And as for the conference? "It was very interesting for me as a new kid on the block!" Klaus says. "It was good to see that a lot of technologies and talks are in line with my thinking on a leading role of Europe in the Digital Economy."

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ARTEMIS TECHNOLOGY CONFERENCE 2019

by JOSH GRINDROD

ADDRESSING THE MANY REVOLUTIONS

When you think of the industrial revolution, Amsterdam may not be the first city that springs to mind – but maybe it should be. Almost 500 years ago, in the time of Rembrandt, the Netherlands had just achieved the highest standard of living across the whole world. Part of this was due, of course, to advanced shipbuilding methods that opened up the port of Amsterdam to the far-flung corners of the globe. Less well-remembered, however, are the domestic innovations that took place in wind, water and peat. Canals and windmills, often underestimated today as merely the backdrop for postcards, were foundational technologies that paved the way to the more famous revolutions of the eighteenth century – not only in the Netherlands but in Great Britain and the United States, where the canal systems were emulated. You might say that Amsterdam was ahead of the curve, making it a fitting location for the ARTEMIS Technology Conference 2019.

A TRADITION REBORN

Located at the elegant Steigenberger Airport Hotel, this year's conference brought together more than 30 speakers from a diverse range of organisations within the ARTEMIS community. As the first of its kind in three years, this conference also provided dozens of opportunities to assess the ever-changing state of affairs, to reunite old colleagues and to make new connections. While ARTEMIS has seen a great deal of success in the last 15 years of operation, new challenges are constantly emerging for our 200 members, European society and the world as a whole. How can we unlock the full potential of Embedded Intelligence and retain our leadership in key areas of the value chain? How do we reach Level 5 automated driving without taking undue safety risks? Does a hybrid approach to systems health hold the key to the next stage of predictive maintenance? These are the sorts of questions that were grappled with in Amsterdam from April 16 to 17.

THE COMMUNITY SPIRIT

Jean-Luc di Paola-Galloni, President of ARTEMIS-IA, kicked off the proceedings with warm words. "We are a community, and it's very important that the community meets on a regular basis, that we share the topics at stake. It's a good tradition." As in many of the conference's talks, the idea of being on the cusp of a transformation looms large. "We are living in very interesting, transitional, if not revolutionary times," Jean-Luc continues. "Our digital thinking on this continent is being challenged. We need to be open and accept those challenges. On the other hand, some of those challenges appear as clear threats. Whether we belong to laboratories, SMEs, start-ups or larger groups, we have to take certain responsibilities. We need to be outcome-oriented, intelligence deliverable-oriented, so that we can protect what we can nurture in the future and play our role in a globalised world while sending a clear message when sovereignty is at stake."

COVERING ALL ANGLES

In this issue of the ARTEMIS Magazine, we speak to just some of the many distinguished guests who attended this year's conference. From the automotive world, Lucie Beaumel shares the technological challenges faced by EGVIA, while Martin Törngren uses automated driving as a jump-off point to analyse Cyber-Physical Systems today. Digital twinning plays a role in both Jeroen Voeten's look at timing bottlenecks in component-based software and Michael Paulweber's unveiling of ENABLE-S3's validation results. Elena Tsiporkova and Stefan Poledna examine, respectively, data-driven system health monitoring and the convergence of IT and OT. With the project now two-thirds of the way through, four representatives from AutoDrive give a comprehensive overview of their journey so far. Klaus Beetz of Siemens, meanwhile, gives the rundown on how digitalisation revolutionises the production chain. Finally, the conference saw the release of *Embedded Intelligence: Trends and Challenges*, a study by Advancy which is discussed by Jan Lohstroh and Saad Khaled. This detailed report sets a path for Europe in which leadership in key domains can be retained and strengthened. In the words of Jean-Luc, "the ARTEMIS community represents the biggest chunk of what will be the future of the value of digital. Any future programme should be readdressed and rebalanced to take this into account."

ATC2019

16-17 April - Amsterdam

MARTIN TORNGREN

written by

JOSH GRINDROD

A NEW ERA FOR CPS

JUGGLING FOUR BALLS

Professor Martin Törngren is no stranger to complexity, least of all when it comes to Cyber-Physical Systems (CPS). Through his work in California, New Jersey and Stockholm's KTH Royal Institute of Technology, Martin has developed a clear understanding of the current state of affairs, implications and directions in a new era of society-scale CPS. At the ARTEMIS Technology Conference 2019, he shared his insights into the risks and benefits – and his unexpected juggling skills.

10,000 YEARS IN THE MAKING

"My investigations into cyber-physical systems really took off last year when I had the opportunity to do a sabbatical in the US," Martin begins. "I was working with the systems engineers of the Stevens Institute of Technology on how to deal with the unprecedented complexity in CPS, our environment, our organisations and our tools. We can look at that from a quantitative point of view – number of lines of code, number of dependencies, etc. – but we can also look at it from the point of view of the people and organisations that have to deal with that complexity as a subjective concept. As humans, as big teams, we have certain capabilities and limitations."

Part of this relates to how we deal with change. After all, Martin notes, our brains were shaped tens of thousands of years ago on the savannah and the stress we experience in new situations can be explained through a better understanding of this. Nonetheless, we live in a fast-changing world. Since 2000, more than 50% of companies in the Fortune 500 have disappeared after failing to ride the digitalisation wave. Not even those with almost complete market dominance are safe, as the case of Kodak has shown. Martin cites Amara's Law: we tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.

"A month ago, I gave an open talk at KTH about trends in CPS, including aspects of control and automation. Some of the general public came back to me and told me that it's Hogwarts incarnated. That was an interesting revelation for me," continues Martin. "We have to think about how people understand these complex systems. How do we explain them? How do we gain trust?"

THE SCENARIO SHAPES THE SYSTEM

Automated driving is a prime example of a much-hyped technology, due to its strong innovation potential. This area faces enormous challenges, in part because human drivers often don't follow the rules. "We are putting these cars in environments with an unlimited number of scenarios, so we have to have a corresponding complexity mirrored in our systems. We are essentially replacing humans in the cars. We can think of human capabilities as having (at least) three levels: our cerebellum (the motion control centre), the ability to think fast (intuitive and quick responses) and the ability to think slow – to reason." To a round of applause, Martin demonstrates his cerebellum with the aid of three juggling balls. Automated cars share this ability to precisely control their motion. However, an audience member is then encouraged to throw a fourth ball; the angle and speed take Martin by surprise but he catches it and continues his routine. "When humans see a scenario that we have never seen before, we may still be able to deal with it. That's a level that we can still not program."

The large investments in automated driving are clearly motivated by the huge revenue potential of the transportation market, leading to a modern-day gold rush in which many companies 'dig' but there are few broad collaborations. Amara's Law is a key factor in this, as is the comparatively unregulated nature of the technology. Simultaneous gold rushes, in areas such as artificial intelligence, Internet of Things and automated driving, make up an ongoing technological revolution. History shows that such revolutions take time – the steam engine took 150 years to change society – but Martin is unequivocal in his belief that we have the power to shape these revolutions ourselves.

THE ARTEMIS FACTOR

When it comes to new technologies, a balance must be found between a precautionary approach that may limit innovation and discourage adoption and a risk-taking approach which assumes that the vast majority of new innovations are beneficial and pose little risk. "If you go to Arizona or Pittsburgh, you will find open-street testing of automated driving. You are part of the experiment. Did you sign any papers to be part of it?" Martin asks. "This, in my mind, provides an example of an unbalanced introduction that introduces too much risk. Failures will occur. The automation paradox means that the higher the capability of automation is, the more difficult it will be to step in when needed, and also the less training you will get as an operator."

Paving the way for trustworthy CPS is an area in which ARTEMIS can play a vital role. "In CPS, there's moreover a need for education and renewal. Some students are taught cybersecurity, some are taught safety, but there's very little cross-interaction," argues Martin, noting that education has a relatively low status in much of the world despite the growing complexity of systems. "We also need new training for practising engineers. Life-long learning is becoming increasingly important and so it's very important that industry and academia come together to raise this issue. There is a potentially competitive advantage here for ARTEMIS if we push for this."

Martin cites sustainability as another area in which ARTEMIS can make a difference – 91% of the world's population currently lives in places in which air pollution exceeds the World Health Organisation's limits. "Considering how we spend resources on earth, for me, this brings a really strong case for circular economies: combining CPS technology with business models to create value out of a sustainable economy. Here too, ARTETMIS can help and drive things in the direction of circular economy.

Finally, we have many projects at ARTEMIS and I think there is the potential to increase the sharing and reuse of these. We should not be trying to invent the next Google, we should be fighting for CPS, for edge computing and smart, trustworthy systems. Europe already has a stronghold here and so it's here that we can leverage our strengths."

ATC2019

16-17 April - Amsterdam

LUCIE BEAUMEL

written by
JOSH GRINDROD

SEEING THE BIGGER PICTURE

THE TECHNOLOGY CHALLENGES OF AUTOMOTIVE

2019 is a big year for the European Green Vehicles Initiative Association. In addition to turning 10 years old, having been formed in the wake of the financial crisis, they were also found in their Impact Assessment to have contributed significantly to the consistent and sustainable growth of automotive R&D spending. This in turn has led to a great deal of highly skilled job creation within the EU. As EGVIA's Head of Office since 2015, Lucie Beaumel understands better than most the technology challenges that lie ahead in the automotive domain – as well as the solutions and collaborations that can speed up the transition to greener road transport.

EGVIA IN A NUTSHELL

Beginning life as the European Green Cars Initiative, which funded 113 collaborative research projects, EGVIA evolved in 2013 into a contractual Public Private Partnership (cPPP) as part of the 'Smart, Green and Integrated Transport' challenge of Horizon 2020. "We worked under the leadership of DG RTD [the European Commission's Directorate-General for Research and Innovation] and we set up an association to engage with the Commission," explains Lucie. "We now have 84 members in the association and most of them – of course, this will not be a big surprise – are automotive community representatives, although we also have representatives from the smart system community and the smart green community. Although we are representing the private side, we also include universities and research centres, so it's a really broad community with some of the major players in the field."

The statistics speak for themselves: with a total budget of EUR 750 million and the participation of 179 SMEs, EGVIA funded 65 projects and published 25 topics between 2014 and 2018. "From the very beginning, we have been supported by three technology platforms," says Lucie. "One is ERTRAC, which is a technology platform for road transport. We also have support from EPoSS and what was called Smart Grid at the time but has now turned into ETIP SNET. Together, the three platforms and the members of the association have drafted the roadmap of the partnership, detailing research areas in the field of improvement of energy efficiency of vehicles using alternative powertrains."

A EUROPEAN EXPLOSION

Today, automotive research in Europe is driven by the promises of automated driving and the necessity of decarbonisation, both of which are heavily R&D intensive. At first glance, it appears as though not much has changed in Europe since 2007, with automotive spending remaining at a steady 45% of the global total. However, this obscures the fact that the amount spent in Europe per year has jumped from EUR 28 billion to 56 billion in that relatively short space of time. Lucie: "Because this trend of decarbonisation is so important, we decided to update our electrification roadmap. This has been a common task of the three technology platforms in the partnership. With this new roadmap, we have decided to take a slightly different approach – instead of the technology, we are starting with the user perspective."

To demonstrate the new approach, Lucie outlines the four initiatives that make up this roadmap to 2030:

1. Operation System dependent electric vehicles (EVs) in the urban environment
2. User-friendly, affordable EV passenger cars and infrastructure
3. 'No compromise' electric urban bus system
4. Sustainable, electrified long-distance trucks and coaches

Referring to the integration of vehicles in urban areas, Lucie considers how they plan to do this. "With vehicle technologies and improvements to traffic system technologies, including controlled traffic flow, enhanced connectivity, Internet of Things and automation, of course." When it comes to electric vehicles, EGVIA is thinking not only about the methods of charging but the experience of charging for users. "It will also not be a surprise that the capacities of today's batteries are not good enough for customers. More research into this field must be done, as well as into advancements in electric motors for electronic charging systems, powertrain efficiency and reducing the need for rare earth materials."

Based on the discussions that went into this roadmap, it was soon realised that focusing solely on vehicles or users would not be enough to overcome the challenges facing automotive. "We want to put green vehicles into more of a system approach so we can cover the different areas needed to meet the targets," says Lucie, noting that vehicles' environments consist of diverse factors such as infrastructure, logistics, fuel and intermodal transport. "We really see that there are two main trends in the automotive sector right now. One is still green as, despite 10 years of really good work from project partners and coordinators, we have still not yet achieved our target in terms of CO_2 reduction. The other, of course, is the digital part, including connected and automated driving."

COLLABORATION IS KEY

EGVIA doesn't simply view these as two separate trends, but rather sees the intersections between them, such as opportunities for charging station integration and managing vehicle access to cities. This recognition has informed their proposal for Horizon Europe: System Challenge Road Transport. From a green perspective, this aims to further reduce CO_2 emissions and greenhouse gas emissions, support the large-scale uptake of renewable energy in transport, limit congestion, improve air quality and reduce noise emissions (especially in urban areas). At the same time, its technological developments can drastically improve road safety, support jobs and growth all over Europe and ultimately improve the acceptance, affordability, accessibility and inclusiveness of mobility solutions.
When examining this bigger picture, it's immediately clear that the involvement of non-automotive players is a must. "We are really pleased to see that EPoSS and ETIP SNET are still willing to support our activities, and that ALICE (logistics technology platform) recently joined the group" says Lucie. "A non-exhaustive list of research areas that need to be investigated includes: the improvement of energy efficiency using better control software and advanced thermo-management systems; the improvement of electric, electronic and embedded software architecture; the development of smart sensors; the reduction of emissions thanks to Embedded Intelligence; the validation of vehicles and infrastructure; and the improvement of latency and reliability."

In Lucie's view, it's naïve to say that even the biggest players can 'solve' these issues within the next few years – but cross-domain collaboration can certainly make an enormous difference. EGVIA, for instance, is already involved in the ECSEL Lighthouse MOBILITY.E project and its network continues to grow. Lucie ends on a positive note: "We are looking forward to having closer discussions with the ARTEMIS community and ECSEL to be sure that the expected impacts of this picture will become a reality."

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REINER JOHN

written by

JOSH GRINDROD

AUTODRIVE

FOUR PERSPECTIVES AFTER TWO SUCCESSFUL YEARS

"We make driving as safe as flying." This is the motto of AutoDrive, the European project bringing together 60 partners for the development of connected, electric and highly automated vehicles. As the project enters its second year of three, the goal remains to make future mobility safer, more affordable and more acceptable to the general public. With such a broad scope, AutoDrive is by necessity divided between 10 supply chains (SCs). At the ARTEMIS Technology Conference 2019, four representatives from these chains shared their views on the progress so far and the work still to be done.

AVOIDING TUNNEL VISION

Reiner John, Director of R&D-funded Projects at Infineon Technologies, introduces the discussion with a bold statement: "The Google Car is the past. It doesn't have a fail-operational powertrain. The perception system will report a failure everywhere and the car will stop, but this is not what you want to happen in a self-driving car. Forget about that."

Technological challenges are not the only obstacles to automated driving; human concerns are also an enormous factor. Acceptance will rely on cars becoming much safer than human error, and humans will certainly not accept any chance that their children could be stranded by a roadside in the event of operational failure. "If a car stops in a tunnel, all the people in the tunnel might be affected." Reiner notes that accidents in such a scenario are 10 times more likely than on open roads. "This is the situation we can face in the future with highly automated cars.
AutoDrive isn't focused solely on passenger cars but on mobility in all its forms. Referring to automated aeroplanes, Reiner says, "if we are 1000 kilometres over the sea, there is no safe space to land. We are looking in our project at systems in aviation. This idea behind this is to go further, go safer, go greener. Making cars safer helps aircraft and this is all included in the thinking." Today's technology is domain-based and relies on distributed E/E architecture. AutoDrive envisions a future with vehicle-centred E/E architecture with vehicle functions in the cloud.

BREAKING DOWN THE COMPONENTS

SC1 is focused on fully-automated driving and flying systems targeting SAE Level 5, at which point zero human intervention is required. Christian Thulfaut of Robert Bosch GmbH steps in to discuss the technology behind this. "Supply chains 1, 2 and 3 are application supply chains, so we are building up demonstrators to really show that the concepts we develop are a reality."

SC1 focuses entirely on sub-systems: power distribution systems, power supply/battery systems, intra-vehicle communication and powertrains. Ensuring that each component is independently fail-operational is a key goal – and expensive. When it comes to Unmanned Aerial Vehicles (UAVs), which should be able to fly 5400 kilometres over 40 hours, Christian reveals that customers often implement components that cost 10 times the price of the UAV itself. "It's important that the aircraft doesn't crash, not because of the aircraft but because of the measurement techniques included."

The UAV Antares E^2 is SC1's first demonstrator, the other being automated shuttlebuses. The two have more in common than meets the eye. "We have an identical system in both worlds," Christian explains. "Each battery module is equipped with a monitoring electronic, so we can sense voltage temperature and current. This chip allows a charge equalisation between these modules and it controls the heating of the battery cells, so there is some intelligence included there. Even if one communication line fails, we still have complete performance of our battery." A 6-phase aviation inverter system is also currently being simulated. Once implemented in the aircraft, it should allow for a temperature stability of up to 120 °C and reduce the thermal capacity of the aluminium housing, saving 300g in total weight.

For shuttlebuses, the idea is to create 'safe stop locations' for the vehicles to travel to following an initial failure. "We have introduced a metric to describe what safe stop location and safe stop level mean. You can describe these levels by manoeuvres. Levels 4 and 5 mean rightmost lane or emergency lane, Level 2 means a parking lot. From these manoeuvres, we can quantify targets such as the speed we need in degraded mood, how far we have to drive and what this means for congestion. This gives us the specs for dimensioning the components, like the battery system and fail-operational powertrain." These powertrains, while being tested in shuttlebuses, form a validation platform for all sorts of vehicles. "We have chosen a multi-machine architecture," says Christian, "because we have great scalability and modularity and we can test a lot of control strategies if we have multiple engines at hand."

THE HIGHEST LEVEL OF SAFETY

But what actually is the difference between fail-operational and fail-safe? Michael Stoltz, a researcher at Virtual Vehicle, explains. "In fail-safe systems, a fault can occur either in hardware or software for many different reasons. In usual systems, there is a human as a fallback, so in Levels 1 and 2 the human is always waiting to take over if the automation fails. In fail-operational circumstances, we are not in a position to hand over to a driver or shut down the system. There must be a back-up strategy to go into some kind of degraded mode and continue operation until we get into a safe situation again."

Michael is part of SC3, which investigates fail-aware, fail-safe and fail-operational behaviour of active safety systems. Uniquely, these overrule other automation systems for as long as is necessary. "That's really the last line of defence," says Michael. For SC3, safe and robust perception of the environment in all conditions is both the goal and the biggest challenge. Critical scenarios and events must be defined and particular attention must be paid to the detection of vulnerable road users.

Unsurprisingly, SC3 includes partners from across the entire value chain: OEMs, Tiers 1 and 2, semiconductors, universities and research institutes. Michael proceeds to outline the demonstrators that have resulted from this collaboration. "These are cars that will host different algorithms. The first, by Virtual Vehicle, will have an emergency braking system and emergency evading system, which are co-operative and will show that if evading is not possible, we can still fall back on braking. In the next demonstrator [JAC], an HMI will be installed to inform the user if there is a fault or failure in the system and what the consequences are for the trip and for the user."

"Flanders Make will show their fault tolerant lateral controller and they will test this by inserting faults into the system and proving that a double lane change is still possible. AVL will also contribute a hybrid pilot use case, and a lane change safety concept will be presented. Additionally, from KTH university, we have a demonstrator car that will always check if there is a possibility to enter the emergency lane and perform a safe stop. At the actuator level, there will be an active power distribution and health prediction test board, provided by Kromberg & Schubert."

CHOOSING THE BEST APPROACH

Closing the discussion, Jorge Pérez brings up the differences in solution approaches to fail-operational behaviour. As a Development Engineer at ZF Friedrichshafen AG, Jorge works on powertrain technology in SC4. "How do we design technological systems? As already mentioned, there is a common understanding that fail-operability means that the vehicle should keep working after a single failure, but this is maybe hard to break down into specific requirements for the system."

In SC4, there are three solution approaches:

1. Redundant system architecture
2. Hardware and software strategies for fault-isolation
3. Fault prediction: fail-aware methods

In the first approach, in which critical components are duplicated to increase reliability, an important priority is choosing between over-dimensioning and degraded functionality. "Do we like to have an over-design system that is capable of giving more power in the healthy scenario, so that after a failure we are still capable of performing at 100% power?" Jorge asks. "Or, in a healthy situation, do we want to provide 100% power and after a failure we degrade to a lower performance?"

Redundancy alone is not always a solution. SC4 has developed two electrically-separate 3-phase systems that can theoretically provide 50% power after 3-phase system failure. However, these 3-phase systems are still magnetically coupled. To isolate faults, Jorge cites an electro-magnetic design as a way to reduce inductive coupling, while software solutions can help to detect fault types and select an appropriate safe-state. These first two approaches both rely on a degree of redundancy, which may not always be possible. Sensors and signal analysis can thus take over fault-detection so that the driver can detect vehicle degradation. "As we can see, there is some technical work underway that can solve these fail-operational problems," Jorge concludes. "This is still an open field, even though within the project we have a clear understanding of what it means to be fail-operational."

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JEROEN VOETEN

written by
JOSH GRINDROD

DIGITAL TWINNING

ANALYSING MILLIONS OF LINES OF CODE IN AN AFTERNOON

As with digital twinning, there's something of a dual nature to Jeroen Voeten: not only is he a research fellow at ESI (TNO), he is also a professor in the Department of Electrical Engineering at Eindhoven University of Technology (TU/e). With an interest in model-based performance engineering techniques for cyber-physical systems, Jeroen has been working on a measurement-based approach to obtain insights into timing bottlenecks in large-scale, component-based software systems. At the ARTEMIS Technology Conference 2019, he shared the technology behind this and the successes that have already been seen.

NANOMETRE ACCURACY

"I will start with a bit of context. These days, most of us have a smart phone. If you look inside, you'll see a tremendously complicated system, all fuelled by Moore's Law," begins Jeroen, pointing to the fact that the number of transistors in dense integrated circuits has been doubling roughly every two years since at least the 1960s. "This smart phone has the same computational power as the Cray system in the seventies, which weighed about as much as an elephant and used the power of fifteen households. We now have that in our hands. And that fuels our digital roadmaps."

To illustrate this point, Jeroen zooms in on a chip inside a smart phone. You could be forgiven for mistaking it for a cityscape, with transistors rising one after the other like a Manhattan skyline. "A chip is grown layer by layer by adding and removing material at nanometre scale," explains Jeroen. "If you take a human hair and slice it into 50,000 pieces, you get about a nanometre. " A key enabler of this is lithography, an exposure process in which light is used to transfer a pattern of a layer of chip to a chemical photoresist on a wafer. "This is done by ASML lithography machines, which are made in the Netherlands," Jeroen adds, with a hint of pride. "ASML is the world leader, so basically almost every chip made in the world goes through one of these machines."

To obtain high productivity and accuracy, wafers must be exposed in a single smooth movement. "For this purpose there are many millions of lines of code constituting hundreds of software components that operate in real-time. " As these components run on the same execution platform and use shared resources, a slight delay by one can influence the timing of another component possibly disturbing the smoothness of the exposure. "The tricky part is to diagnose the bottleneck in case this happens."

TIMED MESSAGE SEQUENCE CHARTS

This is where the research of ESI, TU/e and ASML stepped in. "Firstly, we decided to use message sequence charts, which have been international standards for a long time," says Jeroen. "Secondly, because we didn't have models yet, we had to infer them from running lithography machines. That's where the idea of digital twinning came in." In basic terms, a digital twin is a digital representation of a system that allows for analysis and optimisation. Digital twinning is becoming increasingly common across diverse domains – Philips has even expressed interest in developing digital twins of human beings to record and examine health data. In the case of lithography, a subset of message sequence charts called timed message sequence charts was formalized. These capture the execution of component-based software systems in an intuitive way and are amenable to formal timing analysis.

"The results so far have been tremendously positive: the twinning approach has shown to be able to deal with millions of events and drastically reduce the time to diagnose bottlenecks."

Jeroen: "Timed message sequence charts consist of events, modelling the start and end of executions, and dependencies between events, implying that an event should precede another event. On top of these dependencies we pose timing constraints, specifying the minimal distance in time between them. " This enables a differentiation between two kinds of constraints: critical and non-critical. Critical constraints cause timing variations to propagate through the system, whereas non-critical delays have 'breathing time' making them absorb timing fluctuations and preventing other components from falling out of sync. Bottleneck diagnosis is now merely a matter of working backwards through the trail of critical dependencies.

TAKING THE NEXT STEPS

The results so far have been tremendously positive: the twinning approach has shown to be able to deal with millions of events and drastically reduce the time to diagnose bottlenecks. This successful validation has led to a positive reception by ASML's architects and developers. "For ASML, this was a very important next step in the evolution of their complex systems," Jeroen says. "They are actually incorporating it into their development processes."
In many ways, digital twinning is still in its infancy, and so research like this will almost certainly prove to be a foundation for future breakthroughs. Jeroen himself notes that advanced analysis and optimisation capabilities can still be greatly improved on, citing trend and anomaly detection, automated timed property verification, sensitivity and robustness analysis and what-if analysis as next steps for the technology. "Many complex systems are using the same kind of component-based software architectures, so the approach will likely be applicable in many domains with many advances to come." For Jeroen, and systems analysists everywhere, there's a lot to look forward to.

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STEFAN POLEDNA

written by

JOSH GRINDROD

SHAPING THE CONVERGENCE OF IT AND OT

AN ALTERNATIVE TO UTOPIA

As a co-founder of TTTech, Stefan Poledna has seen a lot change over the last 20 years. With the motto "advancing safe technologies, improving human lives", the company has expanded to more than 1700 employees in 13 different countries and five focus areas: Automotive & Automated Driving, Aero & Space, Off-Highway, Energy and Manufacturing. At the same time, Stefan has increasingly witnessed the need for a convergence of Information Technology (IT) and Operational Technology (OT), a future which we have the power to shape. At the ARTEMIS Technology Conference 2019, he not only made clear the many benefits of this for industrial automation, but also unveiled a standards-based open communication platform to make it a reality.

THE CURSE OF THE AUTOMATION PYRAMID

In 1908, Ford introduced the Model T and the concept of manufacturing lines. This idea remained effective for over 100 years, but has been severely challenged by the digitalisation of the manufacturing industry. Stefan begins by outlining the automation pyramid, around which many industrial organisations are based today. "At the lowest level, you have the physical system, the operations technology. This is about the sensing, the machines, the actuation – all the concrete interactions. The next layer is the control layer. You have PLCs, which in essence control those machines that sense and actuate these devices." Conversely, the top two layers, an MES Level for execution and ERP Level for resource planning, are IT-based and typically use Ethernet.

"If you want to make certain improvements in manufacturing, then it's really about feedback loops and control loops," says Stefan. "Because you need to understand what's going on to improve. Usually, there are two main aspects that you're interested in. One is your cycle time, how long it takes to build a product, because the quicker you can do it, the more output you have. The other one is clearly the quality of your output." This is where the classic pyramid becomes a hindrance. A large number of feedback loops must be analysed to fully understand a system, yet the heavily divided and possibly heterogenous layers allow for only a partial picture.

Naturally, Stefan isn't the first to spot the issue here and adds an additional aspect: "What you want to do is maybe get new value for installed machines because you have usually very expensive assets. Maybe you want to reduce maintenance overheads by having scheduled or preventative maintenance," Stefan says, citing centralised software deployment, access rights to machine data and improved machine optimisation as other reasons to use such an app. Storing this information in the cloud, however, may pose a whole new set of problems.

SOMETHING IN BETWEEN

"If I want to do everything from a single point of control (and it might be the cloud), the question is where this functionality is really running," explains Stefan. "What if this is time-sensitive? What is going to happen if my internet connectivity is not in place? What if the timing of the output must be very precise? What is going to happen if there's a failure or incident? What if the data is leaving my premises? Am I happy with that?" In the cloud, functionality is easy to control, but non-functional aspects – such as safety, integrity and availability – are far trickier.

Fog computing, also known as edge computing, is a solution for these challenges. This architecture approach revolves around a smaller or hybrid version of the cloud on your premises, connected to the cloud to allow deterministic, real-time access and guarantee of non-functional properties like e.g. saftey. This is used to reduce uncertainty. "My take on this," says Stefan, "is that going to a fully cloud-based architecture for industrial automation is utopia. This is not going to happen. In the future, we will have something like an intermediate level called fog or edge. Now the question is, is there a technology available that can talk on the enterprise side and on the automation side?"

THE BEST OF BOTH WORLDS

Time Sensitive Networking (TSN), a set of Ethernet sub-standards, may be the answer. Stefan: "On the enterprise side, Ethernet is effective, there's no question about that. On the physical side, there are a number of Ethernet implementations and most are propriety, so they don't interact with each other. That's a challenge. Ethernet uses message queues, so data coming in is switched to output queues and the output queues are currently treated with priority. You didn't used to have the possibility to open up a queue at a very specific point in time."

TSN have changed this. By providing time synchronisation for networked devices and scheduled forwarding of defined traffic flows, these mechanisms deliver deterministic communication over standard Ethernet. This in turn enables the convergence of critical control traffic with data traffic over one infrastructure and removes the need

for proprietary solutions or gateways. "This was strongly driven by a number of players. We teamed up with Cisco to drive it towards standardisation. This extension enabled, for the first time, Ethernet to have all the capabilities and features for real-time and safety processing in a standardised form."

The next step is to make this system interoperable for those who already have Ethernet. One solution which already has a great deal of market traction is OPC UA, a data management system for information exchange in distributed systems. This follows a client-server communication model for sharing data between machines and the cloud, in which machines can identify themselves by name and offer services. "The only thing that it's not really suitable for," concedes Stefan, "is cyclic or real-time data exchange. If you have a lot of different sensors, this route is a bottleneck that won't be effective." An answer comes in the form of PubSub (publish / subscribe), an extension to OPC UA that enables multicast communication, allowing servers to publish data without a specific client. Clients can then subscribe to any published data.

"If you want to make certain improvements in manufacturing, then it's really about feedback loops and control loops, because you need to understand what's going on to improve. "

The final result, OPC UA PubSub over TSN, has a number of clear advantages. Stefan: "You have an open infrastructure for industrial automation that goes up from the enterprise resource planning down to the sensor level. It's open and standards-based. It's interoperable and it can scale, so you have solutions from 100MB to 10GB." As if that wasn't enough, most of the major automation companies are now committed to TSN and OPC/UA. TTTech is taking a seat on the steering committee in the field level initiative of the OPC foundation.

TAKING IT TO THE NEXT LEVEL

In many ways, this result is a testament to the strength and possibilities of European co-operation, having been comprised of just a few companies when efforts began three years ago. As platform building support, a number of projects have now been co-funded by the EU's Horizon 2020 Framework Programme, including 114 partners working on the TSN core and fog computing and 49 involved in fog orchestration virtualisation and the platform itself. The first products supporting TSN, such as the Kontron PCIe TSN card, have already been released. "In a way, we are neutral because we are only concerned as a company with the safe and secure transport mechanisms and real-time guarantees," adds Stefan. "We are not in any way active in the applications."

He concludes by summarising the concrete outcomes so far: virtualisation and workload consolidation at a fog level, seamless access to data from sensors to the fog to the cloud, full remote orchestration, real-time safety networking and integrated and distributed safety control. "We think that on the communication side of things, OPC UA over TSN is really a very promising platform. It recently got a lot of industry momentum and acceptance and it's a great solution to really bridge this IT and OT problem."

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ELENA TSIPORKOVA

written by
JOSH GRINDROD

KNOWLEDGE VS DATA

A HYBRID APPROACH TO SYSTEM HEALTH MONITORING

"As far as the laws of mathematics refer to reality, they are not certain, and as far as they are certain, they do not refer to reality." Elena Tsiporkova, Head of EluciDATA Lab, The Data and AI Competence Lab of Sirris, uses this Einstein quote to make one thing clear: when it comes to system health monitoring, it's a question of combining data-driven and knowledge-based modelling, not choosing between them. At Sirris' Data and Artificial Intelligence Competence Lab, experts have been working to stimulate data innovation and the uptake of AI. At the ARTEMIS Technology Conference 2019, already very promising results for photovoltaic (PV) plants were unveiled.

UNDERSTANDING THE ABNORMAL

Elena begins by mentioning that this investigation, performed in cooperation with 3E (an innovative SME active in renewable energy consultancy) and part of both a PhD research and the EU's MANTIS Project, aimed at using maintenance to create additional value in business processes, new business models and stronger service orientations. MANTIS no doubt reflected an increasing interest in gaining insights into the behaviour of complex industrial machinery and systems. "We are mostly dealing with fleets of assets," says Elena. "This is a very broad concept and could be a fleet of wind turbines, a fleet of vehicles or a portfolio of production lines. We are also interested in understanding their manufacturing alliance. These days, people even want to be able to measure performance at the level of electronic components. This is all very exciting, but there are still a lot of challenges."

"AI and machine learning alone will not solve the problem. We always need to choose the method for modelling a system based on how much we know about the phenomenon and the data we have. "

that you're going to create from the data-driven services is something that you're going to benefit from continuously." New business models are needed to change the attitude of companies to data ownership and sharing; meanwhile, a way to examine the interactions of multiple entities in a system and the impact of external factors is necessary to create value from shared data.

A BUCKET OF INFORMATION

"AI and machine learning alone will not solve the problem. We always need to choose the method for modelling a system based on how much we know about the phenomenon and the data we have," says Elena, outlining the two major approaches. In a knowledge-driven approach, rich domain knowledge (including physics) and specific data are used to create robust models with predictive capacities. However, these are generally not scalable. Conversely, a data-driven approach relies on access to comprehensive data with a limited knowledge of the underlying mechanisms. Explorative models therefore aim to develop new ideas and build hypothesises. "You're looking at a bucket of data," laughs Elena. "You don't know what you will find."

The best solution, she argues, will be somewhere in between the two approaches: a hybrid of traditional engineering and data-driven analysis. Well-understood physical processes can be modelled at a components level, while complex phenomenon at a systems level can be monitored through continuous data collection. As a proof of concept, Elena points to a recent success story from General Motors in which a physics-based model has been refined using fleet-based data.
"They want to try to alert users before failures happen, but they had very few examples of failures," Elena states. "Big amounts of data, but very little on which you can train a model." Through data-based algorithm refinement and calibration, however, they managed to correlate field data from over 1,000,000 vehicles and subsequently refine failure precursors. Then again, this is General Motors, one of the world's largest automobile manufacturers. "In how many cases do you have access to such a big amount of data?" asks Elena.

One obvious factor is that not every asset can be divided into sub-parts to be monitored separately. Datasets also cause issues, either through low quality (such as missing values and outliers), influencing factors (like environmental conditions) or a lack of 'ground truth'. "It's cheap to put in a sensor and collect the data," Elena explains. "But if we don't know whether there was a failure or not, we cannot do much with this. Machine learning and AI systems work on big trends, on data with which they can predict normal or abnormal." This all relies on the data being available in the first place – it may be owned by many parties in a complex value chain or impossible to interpret without specialist domain knowledge.

Elena: "It's a question of trust. You see OEMs that sell a wind turbine for millions of euros and don't give you access to the high-frequency data. That's absurd. Why not? OEMs are afraid of reverse engineering. On the other hand, you sell a turbine once but the revenue

ANALYSING A SYSTEM WITH THE NAKED EYE

Fortunately, Sirris has its own success story to share thanks to their close collaboration with industrial partners as 3E. The goal? To derive performance indicators for PV plants by quantifying production behaviour as either regular or irregular. At the start of this project, the only things available were the time series of production performance, sensor measurements of environmental factors and event logs consisting of temporal sequences of messages. "We didn't have any explicit knowledge of sub-optimal operation and we had huge volumes of data," Elena notes. "You can imagine that if there are issues, these event logs produce thousands of events per day. They are spitting out warnings and I don't know what, but in most cases the plant keeps working." The sheer amount of data simply obscures notable patterns.

A hybrid approach offered the solution. "We tried using the two types of data we have to derive some characteristic profiles of behaviour and link these profiles to performance. We were then able to say 'if we see this profile, we expect this performance," explains Elena. "To be able to link this to performance, we needed the physics-based knowledge, a model which specifies how much energy you can produce if you know how much sunlight reached the plant." On a technical level, this required segmenting the inverter event logs per day and assigning each event a relevance score inspired by the TF-IDF text mining methodology. Converting these to numerical vectors resulted in unique inverter-day event fingerprints that could be clustered to give 12 different inverter-day behaviour profiles across the entire plant.

Based on irradiation sensors and (in some cases) satellite data, a comparison can be drawn between the amount of irradiation received and the plant's yield. The results can be compared to the inverter-day profiles to estimate how much production has been lost. "In this way, we could build a repository of behaviour profiles which are annotated and labelled with performance. Then we can use well known machine learning classifiers e.g. k-Nearest Neighbour for any incoming profiles, any incoming days, to quickly quantify the performance of the system." Elena even takes this one step further, showing a graph that replaces each inverter-day with a single behaviour profile. With a different colour for each of the 12, this becomes a straightforward visualisation tool that humans can use to spot insightful patterns over time.

A LITTLE BIT GOES A LONG WAY

And as for trust? "You need to in some way convince the domain experts and portfolio managers how important it is to collect data, because all this is going in small steps," says Elena. "If they don't see a return on their investment in data, you'll never be able to get further. Right from the beginning, you'll never be able to build something that predicts. I always get very suspicious when people promise predicting eminent failures from the start of a project. This is the ultimate goal. It will take quite some time and the collection of a lot of curated, labelled data."

Nonetheless, Elena concludes with some words of encouragement: "Even with very little data, you can go further than you think by trying to monitor the performance of health of the system. Although you have quite some challenges linked to not knowing the environmental parameters and not having the output, by using a bit of creativity you can still get quite far."

"It's a question of trust. You see OEMs that sell a wind turbine for millions of euros and don't give you access to the high-frequency data. That's absurd. Why not?"

HIPEAC VISION 2019

In its meeting of April 15, the ARTEMIS-IA Steering Board decided to endorse the HiPEAC Vision 2019. The HiPEAC Vision 2019 is a long term vision on high performance and embedded architectures and low level software (e.g. compiler) and depicts trends, not only on the core of Embedded Intelligence, but also on the contexts of business and social impacts of computing technologies. ARTEMIS-IA welcomes the HiPEAC Vision 2019 as complementary to the SRA on Electronic components and Systems, the ECS-SRA, that goes deeper into concrete application domains, addressing the impact of digitalization on applications. The ECS-SRA identifies the research needs of the essential capabilities in ECS needed for realizing this digitalization by collaborative projects. This is detailed in five application chapters and five chapters on essential capabilities, followed by a longer-term outlook.

The HiPEAC Vision 2019 gives high level key recommendation on the future of computing systems, in the fields of system efficiency, trust and acceptance, the position of Europe and the societal impact of CPS and HPC technologies. This is underpinned by a deep analysis of trends and a vision on the future of System-level directions, Technology directions, Business dimensions, Requirements for acceptability and the Societal dimension. This analysis is concluded by a SWOT on the position of Europe in the world.

ENABLE-S3 PRESENTED RESULTS AT FINAL EVENT

The European research project ENABLE-S3 successfully presented the results of three years of research at the public Final Event May 16-17 May in Graz, Austria.

Coordinated by AVL List, 68 partners from 16 countries had set themselves the goal of establishing a comprehensive platform for the cost-effective validation and verification of autonomous and highly automated vehicles, trains, tractors, ships, aircrafts, satellites and medical examination equipment.

In the course of three years, the research consortium has collaborated across 6 domains and 12 industrial-driven use cases and achieved impressive results. At the Final Event in Graz, the most important project results were presented to project partners, the ECSEL JU appointed reviewers, the project officer, guests and visitors.

To facilitate the understanding and gain an overview of the results, both visitors and guests had the chance to participate in guided tours through the exhibition with more than 40 demonstrators. Additional, exclusive guided tours were organised for the reviewers and the project officer.

To support the collaborative spirit of the project and to connect with people driving innovations in renowned companies, keynote presentations were held by representatives from autonomous driving programmes within Siemens and Intel/Mobileye and the German regulation organisation TÜV SÜD. How the ENABLE-S3 results are already being applied in standardization activities were shown by ASAM e.V. and by the Austrian proving region for automated driving ALP.Lab.

Overall, the presented results were well received and the project consortium, guests and visitors enjoyed the fruitful exchange of knowledge and the collaborative spirit among all event participants.

If you want to learn more about the project results, please check the ENABLE-S3 homepage https://www.enable-s3.eu/media/dissemination-material/

THE PURSUIT OF SIMPLICITY

ACCELERATING VALIDATION WITH ENABLE-S3

by **JOSH GRINDROD**

"When we came up with this idea, I was quite sceptical that it would be possible to define tool chains that can be used in such different domains," begins Michael Paulweber, Director of Global ITS Research & Technology at AVL List and the Vice-President of ARTEMIS-IA. "But we now have more than 40 different applications. We got a very good exchange between the domains." He's referring to ENABLE-S3, the industry-driven verification and validation project that aims to find a balance between the computational limits of pure modelling and the expensive, potentially dangerous realm of real-world testing. As this project comes to a close and the results are made public, Michael outlines the three-year journey and just a few of the proven applications.

TAKING FLIGHT WITH PEGASUS

In many ways, ENABLE-S3 has been a truly monumental effort: 68 partners across 16 countries and six domains have worked together to create a reference architecture for ADAS/AD validation and initiate several standards. "One of the problems is that when you start a project, you have three years to work on it and it takes significant time to reach a common understanding of the specification. You come up with interfaces and you make implementations to prove that it's working," Michael says. "And then your project ends." For this reason, the ENABLE-S3 consortium worked hard at the beginning of the project to define the standards involved and create an ecosystem of interfaces with which to work. This was especially crucial given the unusually diverse range of domains involved – aerospace, health, rail, farming, maritime and automotive players have all benefited so far from the results.

Shortly before the start of ENABLE-S3, the German national proposal PEGASUS had been launched to examine the political and social requirements for automated driving. "Even in our project proposal, we laid out some kind of a collaboration between the two projects," says Michael. "That helped us a lot because the topics we are dealing with are really large and we need more than one project. Whether it's an ECSEL project, a German-funded project, an ICT project, whatever it is, we have to get this cooperation going." Michael chooses to hone in on the automotive domain for an example use case, posing a question that ENABLE-S3 has contributed to answering: how do we make sure that automated vehicles behave safely and correctly in *every* situation?

A COMPLEX SYSTEM IN A COMPLEX ENVIRONMENT

"The problem in this case – and it's the same for a ship, an aeroplane or an MRI system in health – is that there's a big difference in what our control systems are used to. There is a barrier between them and the outside world, and that's the human," Michael explains. "The human senses what is going on in the outside world and converts it into accelerating, braking or steering. In an automated system, that's not the case anymore. Suddenly, the outside world is a part of it." An already highly complex system finds itself in an environment with an uncountable number of scenarios, all shaped by a combination of traffic, the weather, road conditions and often illogical driver behaviour.

Thankfully, critical situations occur only rarely in practice, although this can make life difficult when it comes to test-driving a vehicle. Michael: "The companies have to drive lots and lots of miles in order to encounter these situations, especially if you take into account situations dependent on weather conditions. You have to go to the north of Sweden to get snow or ice and you have to go to Nevada or the south of Spain to get really hot conditions. That's a lot of effort." Across the industry, virtual validation has been embraced as a way to speed up this process and reduce the costs involved. However, as Michael puts it, "if you do virtual validation, you have to prove that your virtual system really is a digital print of the real system." If the two don't match to an extremely precise degree, you may as well be testing a completely different vehicle. By bringing together the two worlds of validation, ENABLE-S3 aims to prevent such an issue.

TALKING TERMINOLOGY

Early in the process, it was realised that common terminology was an absolute requirement. "You have to get a common understanding of what certain terms means, even simple terms. We have scenario-based validation so we had to specify what a 'scenario' is." This was taken to mean a formalised description of the multi-actor process, including its static environment, its dynamic environment and environmental conditions. These in turn may include activities, events, goals of the activity and the decisions of actors, and may have parameter ranges or distributions. This first outcome, while sounding superficially straightforward, took the consortium a great number of workshops to iron out.

"The second outcome was the reference architecture," Michael says. "In the end, it was quite simple, as all good things are. We have three layers: the data management layer, the test management layer and the test execution platforms. The important thing is the components [such as system dynamics and sensors] that we put into some kind of database of tools, which were then used in different combinations in different use cases in the different domains. That was the proof at the end that this concept – a reference architecture to create software tool and components that can be reused – makes sense."

PROOF POSITIVE

Michael continues with an example of a demonstrator born through collaboration between TNO and AVL. "TNO has been working for many years on a scenario database where they collect information about what can happen in the real world, structured in a way that differentiates between scenarios that can happen on the highway, in rural areas, in the middle of Europe, in the US, in China. We created a tool that can connect to that database, select the relevant information and convert it in a way that executes these test cases in different test environments. This closes the loop in our reference validation architecture." This is just one of 35 demonstrators that have been developed. Michael points to a co-simulation framework, high-fidelity camera sensor model, test beds with real sensors for dangerous vehicle simulation and radar sensor stimuli as other notable successes.

Ultimately, scenarios are a basepoint and the models derived from these are critical in making ENABLE-S3 a success, as sensor simulation allows for near real-world testing in a safe environment. The interface scenarios have now been handed over to standardisation organisations, guaranteeing sustainability and forming a springboard from which future innovations can emerge. Simple, as all good things are.

"if you do virtual validation, you have to prove that your virtual system really is a digital print of the real system."

EUROPE'S LARGEST PROJECT FOR DIGITIZATION OF INDUSTRY

by **JERKER DELSING**

On May 14 the kick-off for Arrowhead Tools took place at Gothia Towers Hotel in Gothenburg. Among the participants were the Minister for Enterprise and Innovation of Sweden Ibrahim Baylan, Volvo Group Trucks Operations' Jan Ohlsson and the The Association of Swedish Engineering Industries' Klas Wåhlberg, as well as several European business representatives.

"With Arrowhead Tools, it is clear that Europe wants to maintain the lead in the world when it comes to automation and digitization."

Arrowhead Tools is Europe's largest project for solutions in automation and digitization for the industry. Arrowhead Tools has a budget of EUR 91 million and 81 participants, among them some of Europe's largest companies such as Volvo, Bosch and Philips.

The purpose of the three-year project Arrowhead Tools is to create engineering tools for the next generation of solutions in digitization and automation for the European industry. These tools will bridge the gap that currently prevents a total integration of IT and operational technology, i.e. how the industry works towards the Internet of Things (IoT) and "system of systems"; to build large systems using the Internet of Things.
Framework.

MORE ABOUT ARROWHEAD TOOLS

Arrowhead Tools is funded by the participating companies and ECSEL-JU, a public-private partnership for electronic components and systems within EU Horizon 2020, as well as the participating countries (in Sweden through Vinnova).

Luleå University of Technology also led the large automation project Arrowhead, completed in 2017, which produced concrete solutions for interoperability for automation systems.

The purpose of the three-year project Arrowhead Tools is to create engineering tools for the next generation of solutions in digitization and automation for the European industry. These tools will bridge the gap that currently prevents a total integration of IT and operational technology, i.e. how the industry works towards the Internet of Things (IoT) and "system of systems"; to build large systems using the Internet of Things. The new technology will be made available through an open source platform, Arrowhead Framework.

Arrowhead Tools is expected to reduce the costs of developing and introducing flexible and secure digitization and automation solutions by 25-60 per cent. This will make Sweden and Europe more competitive and create new jobs and business opportunities, but also reduce energy consumption and environmental footprints, says Jerker Delsing, professor of Industrial Electronics at Luleå University of Technology and coordinator for Arrowhead Tools.

CREATE DE FACTO-STANDARDS

53 companies from the automotive, mining, electronics and software industries participate in the project. The platform and tools will be tested in 22 industrial user cases. An important goal of Arrowhead Tools is to create de facto-standards in digitization and automation, including interoperability. " There is a great need for common standards. Today, different standards are written in thousands of places. Arrowhead Tools is one of few initiatives that can handle industry demands in the area. Technically, we probably have the most advanced approach available globally", says Jerker Delsing.

The total project budget for Arrowhead Tools is EUR 91 million, where the participating companies themselves account for half of the budget. "This is a joint investment between the industry, the EU Commission and 18 countries", says Jerker Delsing, adding: With Arrowhead Tools, it is clear that Europe wants to maintain the lead in the world when it comes to automation and digitization.

CALENDAR

DIGITAL EXCELLENCE FORUM

19-20 September 2019
HELSINKI, FINLAND

This event will provide an excellent opportunity to present and discuss the main policy drivers of the digital transformation of European industry and society. It will also present how the EU research and innovation agenda can best contribute to these objectives. The event will also present the Horizon 2020 Work Programme, and serve as a unique networking platform for ICT enthusiasts and professionals.>>

EPOSS ANNUAL FORUM 2019

15-17 October 2019
SAN SEBASTIAN, SPAIN

SCANDINAVIAN CONFERENCE ON SYSTEM AND SOFTWARE SAFETY

22-23 October 2019
STOCKHOLM, SWEDEN

2019 IEEE ICCVE

4-8 November 2018
GRAZ, AUSTRIA

The 2019 IEEE ICCVE – International Conference on Connected Vehicles and Expo – is the brand-new application-driven flagship conference of the IEEE Instrumentation and Measurement Society and is the world's premier conference in that field to bridge the automated vehicle gap: Science and Technology, Consumer Trust, Homologation and Liability.

ECS 2019

5-6 November 2019
STOCKHOLM, SWEDEN

EFECS 2019

19-21 November 2019
HELSINKI, FINLAND

EFECS is the international forum with a focus on 'Our Digital Future' along the Electronic Components and Systems value chain in Europe. The organisers of this event, AENEAS, ARTEMIS-IA, EPoSS, ECSEL Joint Undertaking and the European Commission, in association with EUREKA, have joined forces to bring all stakeholders together on 19-21 November 2019.
EFECS provides numerous opportunities to learn more about the latest developments, cooperation and funding possibilities in the ECS Community.

H2020 RTR19 EUROPEAN CONFERENCE

4-5 December 2019
BRUSSELS, BELGIUM

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Submissions:
The ARTEMIS-IA office is interested in receiving news or events linked to the aim of ARTEMIS-IA, related projects or in general: R&D in the field of Embedded and Cyber-Physical Systems area.
Please submit your information to info@artemis-ia.eu

ARTEMIS Industry Association strives for a leading position of Europe in Embedded Intelligence