Software and platforms in Finland 2019–2029

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The purpose of this document
In this document, we discuss the present state of the software industry and the role that the industry plays in Finland based on interviews and background information that we have compiled. We then present a number of measures aimed at developing the software industry.

The goal is to create a foundation for a software ecosystem, operating within the framework of Allied ICT Finland, and to encapsulate the software industry’s views for the benefit of national decision-makers. This report is intended to be used as preparatory material for a national survey fulfilling academic criteria. Such a survey is one of the measures proposed in this report.

Allied ICT Finland: Background
Allied ICT Finland (AIF) is the largest Nordic research, development and innovation (RDI) alliance in the ICT sector. AIF is a national-level cluster that links Finnish ICT research expertise to business.

AIF partnerships
- 18 universities, other higher education institutes and research organisations
- 9 ICT cities represented through business development companies
- 1200+ ICT enterprises
- 13 national-level ecosystems

AIF activities
- Bringing together special expertise
- Strategic initiatives and investments
- National spearhead projects
- Participants’ shared RDI infrastructures
- International business partnerships
- EU and international research cooperation
- Financial services and research-to-business coaching

Aiming at impact
The cluster of higher education institutions, research institutes, business development companies and cities within the AIF network aims at combining regional and field-specific areas of expertise, resources and needs.

Business cooperation as a resource for Finland
The companies in the network implement international product and service solutions for the needs of various sectors.

Team agility and platform economy models
AIF utilizes the latest action models, existing research and the capacity of HEIs and research institutes in a coordinated way.

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Software and platforms in Finland 2019–2029
Digitalisation and the role of the ICT industry in Finland 2019-2029
The digitalisation trend reshapes today’s labour market substantially. As companies update their change management and workforce strategies, they have a genuine opportunity to utilise the latest technologies. Many job roles will be updated, or will be superseded entirely. The development of competence will be the key to success also in the future.

Allied ICT Finland, the partner network of Finnish education and research institutes, cities and companies, has analysed the potential of the ICT industry and the digitalisation trend in Finland moving into the 2030s. It has studied the role and the combined impact of key ICT sectors from the perspective of the industry’s internal development and competitive ability, and from the point of view of the development of individual fields of application. The results of the study highlight the importance of joint development and synergy in four principal areas of focus and spheres of application:

1. Wireless technologies and communication networks
2. Software development
3. Cybersecurity
4. Artificial intelligence

These sectors need to be developed in collaboration, seeking to produce new added value in various spheres of application, such as the development of health technologies and solutions for personalised care needs, the development of the competitive ability of production facilities, the development of digital services for cities and other organisations, and the monitoring and impact assessment of atmospheric changes in climate work.
Fast (near-instantaneous), secure and reliable wireless communications networks and the digital information relayed through them open numerous opportunities for new services and innovations. Together with software, artificial intelligence and cybersecurity, wireless communications forms a shared platform for digitalisation. Finland already holds a strong position in 5G research and commercialisation: key drivers include substantial 4G and 5G radio technology expertise and business competence, a flagship company (Nokia) with an extensive partner network, and the availability of test environments and networks for the development of new wireless technologies and applications. Within the next 2–3 years, Finland has potential to become an important actor in business models that employ 5G solutions. Within the next 3–5 years, a strong position can be achieved in Beyond 5G technologies and research of smart networks and 6G. Within the next 10 years, the commercialisation of 6G and smart networks offer considerable opportunities for Finland.

In a digitalised world, all business is software business. Platform economies are entirely dependent on software. All new business initiatives need new software, and in digital business all business changes are implemented through software. Six of the world’s biggest businesses are software companies. Even the traditional industry is becoming more and more driven by software. 80% of new innovations in the car industry, for example, are implemented through software. Software development and production form an important industry that provides employment for more than 100,000 people in Finland. Software could also become a very important export product – potentially to up to 20–30% of Finland’s exports. As the industry grows faster than the overall economy, important changes may occur within one decade.
Artificial intelligence is considered one of the key technologies of the century and a major change driver that is expected to improve the productivity and the competitive strength of companies and nations. In the development of new ways of improving productivity and refining the results of information access, the role of computational analysis, data mining and cloud-based smart services become more important. Analytics company Gartner has estimated the value of the artificial intelligence market to be 3.9 billion dollars in 2022, and for example Accenture has estimated Finland to be one of the major winners in the sphere of artificial intelligence applications, expected to potentially gain up to up 2.0% in annual cumulative growth of the national product. Advantages of artificial intelligence to the national product are achieved by applying it extensively to the development of new business and the restructuring of the public sector. Existing artificial intelligence applications include natural language processing, pattern recognition, expert systems, robotics and entertainment applications. All current and emerging innovations depend on constant development and renewal of expertise.

In an increasingly technical world, cybersecurity is a key part of overall safety and security. Financial losses caused by cybercrime alone are estimated to increase to 3,000 billion dollars worldwide by 2020. Both the public and the commercial sector need to invest more into the prevention of cyber risks. According to Forbes, the value of cybersecurity products and services was more than 114 billion dollars in 2018 – up 12.4% from the previous year. This year the value of the cybersecurity market will be 124 billion dollars, and it is expected to increase to up to 170 billion dollars in 2020. The cybersecurity industry currently employs approximately 6,000 employees in Finland, and has a turnover of approximately one billion euros. The industry is expected to see rapid growth in the coming years.

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**Government platform**

Analysing the operational environment and the strategic choices of businesses from the perspective of the new government platform is very important. The new government platform will have considerable impact on Finland’s competitive advantage, the growth of the national economy and, consequently, the employment and the well-being of Finnish people. A crucial factor here is the maintenance and development of active and innovative research and development initiatives. Creating high-added-value jobs and attracting investments into the development of high technology play an important role for Finland’s future.

In long-term projects, the prediction of technological developments and the ability to plan projects for the technological environments of the future become very important. As the speed of technological development increases constantly, planning processes have to be dynamic and need to adapt to constant change. This is especially important in social and health care projects, in the development of public digital services and in traffic and infrastructure projects that have long physical construction times, such as railway projects.

Allied ICT Finland (AIF) offers its entire research, development and innovation potential to the support and development Finland’s competitive advantage and economic growth. The AIF partners offer world-class expertise and information based on scientific research. AIF considers close and direct connections between researchers and decision makers of great importance. Because of the accelerating pace of technological development, activating the dialogue on the future outlook of research and development initiatives, opportunities and financing needs is now called for. Members of the AIF hope that these factors are taken into account when negotiating the new government platform, and that appropriate policies and implementation plans are put in place to ensure the future of Finnish expertise, positive development of the employment situation and competitive advantage.
Introduction
Digitalisation makes all business software business. For example, 80% of new automobile-related innovations are based on software. The platform economy also runs on software. New business operations require new software, and as business goes digital, changes to operations are carried out with the help of software. What is more, software is used to open, implement and accelerate most new markets. We can, with good reason, quote Marc Andreessen, who back in 2011, stated that “software is eating the world.” As proof of this, the world’s six largest companies and seven of the ten largest companies are now software businesses. Only one of the ten represents traditional industry.

We often take the present digital change to mean the adoption and use of individual technologies, such as artificial intelligence, data analytics or the Industrial Internet of Things. In this view, development effort focuses on a chosen technology and its refinement. However, digital change is systemic, focusing on large entities: it entails using software to integrate new and old systems and technologies in novel ways to create functioning units. Software is at the core of innovation. It enables the production, transfer, management and processing of data. If data is the new oil, then software is the new machinery of the new industrialisation. Contrary to traditional industrial products, the economy of scale does not come into play in software creation. The larger the software, the more demanding it is to construct, test and maintain. One might conclude that as the size of software grows, the coding involved becomes increasingly demanding. In both present and future digital change, software applications continue to grow in size and become more inherently integrated into their environment. Even though software products also include integrated off-the-shelf components, the overall management of products does not become easier since integration also poses challenges to management. All this results in complex systems, the management and construction of which calls for new methods and approaches from the perspective of company management, society and technological development.

The production of millions of lines of code is not mere “coding”. It also requires new, advanced forms of production competence and management. The modern turbulent business environment also calls for increased agility and experimenting with new ideas. Software engineering involves strict quality requirements, efficient production, innovation, experimentation and agility. Software creation must necessarily become faster, easier and less expensive. In other words, what Finland needs is a leap in software engineering. The ability to create large, complex software that is integrat-

ed into the environment in new ways is critical to the success of society.

In this report, we provide an overview of the present state, problems and future outlook of Finnish software engineering. The report has been drawn up by eight Finnish professors in software engineering. In addition, we have interviewed ten company directors working in the software business. Instead of reading this report as a national survey fulfilling academic criteria, it should be used as the starting point for the compilation of such a survey. After presenting an analysis of the information that we have compiled, we will list a number of proposals for developing the software industry along with a recommendation to carry out a more detailed investigation.
Strategic aspects
We began compiling this report by examining key issues related to the software industry and the present state of the field in Finland. This work involved eight Finnish professors in software engineering. The group comprised:

Kari Smolander, LUT University;
Casper Lassenius, Aalto University;
Ville Leppänen, University of Turku;
Tommi Mikkonen, University of Helsinki;
Tomi Männistö, University of Helsinki;
Markku Oivo, University of Oulu;
Kari Systä, University of Tampere;
Pasi Tyrväinen, University of Jyväskylä

In November 2018, we also interviewed ten Finnish business directors, whose job description involved software engineering or its development. All the companies and organisations that took part in the survey play a key role in Finland in terms of software. During the interviews, we discussed a list of topics agreed in advance. The interviewer took notes, which were later compiled and analysed to produce the results discussed in Chapter 3. In our analysis, we also took into account our own views as well as the answers from one hundred interviews conducted for an ongoing survey of software companies. The interviews and analyses focused on the following topics:

The present and future significance of software to Finland

What significance does software carry for Finland at present?
What would be a good target for Finland and how can it be reached?
What are the major challenges and problems related to software?
What export potential does software offer?

The strengths, development areas and problems related to software

Strengths – which software-related areas are strong in Finland?
How do these strengths show up in research?
Which areas are strong in Finnish business? How can these strengths be seen?
Are there any software-related strengths in public operations? What are the key areas for this type of software?
What software-related robust ecosystems do we have in Finland? Does Finland boast any exceptionally strong collaboration in the field? Does Finland have any powerful software platforms worth pointing out?

Development areas and problems in Finland – what software-related areas need to be developed? What problems need to be solved?

Are there any conflicts between the present state and development needs now and in the future?

What advanced competence do we need in software engineering? What other competence needs are there?

How should education, employment and continuous learning be developed?

What needs for software research exist now and in the future?

How is funding for research and development allocated in view of the needs? The assessment of this question can deal with aspects such as quantity, speed, transparency, impact and allocation.

Are there any significant development areas and problems in legislation (e.g., public procurement) related to, for example, regulation, openness or the platform economy?

What measures should the Finnish Government take to develop the software industry?
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Software creates added value in all fields of industry and operations. The ability to create and utilise software is key in nearly all successful business. However, software-related needs and areas of development and research differ greatly depending on the type of operations. In our analysis, we therefore decided to divide software business into the following four categories:

I. Scalable software export products (e.g., Supercell, F-Secure, M-Files)
II. Driving agents and top specialists, including all fields of the industry (e.g., Kone, Valmet, Nokia, Bittium)
III. Production of high-quality digital services (e.g., Reaktor, Gofore, Siili Solutions, Solita, Vincit, Kela (the Social Insurance Institution of Finland), Tax Administration, Population Register Centre, OP)
IV. Development and maintenance of operational activities (e.g., Telia, Apotti, CGI)

The following analysis includes a report on present conditions as well as an outlook for the future both from a general perspective and from the viewpoint of the four categories.

3.1 The significance of software to Finland

What is the present and future significance of software to Finland?

Software engineering constitutes an important field of industry, employing at least 100,000 people. Around half of the employees work in software companies, while the other half work with software development in other sectors. The field will become increasingly important in the future, seeing as it is growing considerably faster than other sectors and that in most sectors, development and added value are generated with the help of software. This will result in radical change, with companies turning into software businesses. According to one of the directors interviewed, approximately 90–95% of Nokia’s value, for example, currently originates from software. Similar development can be seen in other industrial companies, and the trend is expected to pick up in the near future. Furthermore, software will generate a new leap in productivity as companies move from computer-aided design to a fully digital product lifecycle employing virtual product models. According to the interviewee, software will speed up production processes and supply cycles. For example, in new 5G network systems, rapid design and supply cycles increasingly call for the use of
Software-based FPGA solutions and software instead of hardware-based ASIC design.

3.1.1 What would be a good target state (2029) and how can it be reached?

Software may well become Finland’s largest export product, accounting for 20–30% of Finnish exports, on top of it playing an important role in the production and export of other products. Since the industry continues to grow faster than the rest of the economy, its size will in any case change considerably in the next decade. From 2014 to 2017, the value of software exports doubled, increasing from two to four billion euros. To achieve real success, Finland must focus on its attractiveness and boost its culture of experimentation. We must ensure that Finland offers world-class conditions for the creation, identification and implementation of innovations instead of providing mere coding competence. We should aim at scalability – or perhaps even at superscalability. Finland needs two to five globally superscalable success stories similar to those of the gaming industry.

The software industry is heterogeneous to say the least, which is why, for the purpose of our analysis, we decided to divide the organisations into four categories, which differ from each other in terms of their target state.

I. Scalable software export products (e.g., Supercell, F-Secure, M-Files)
This category includes software and software-based services that are globally scalable for large user groups. This means that their markets are also global. The goal should be to considerably increase the number of such companies. The overall annual turnover could amount to, for example, 10 billion euros. This calls for funding and a general attitude supporting ambitious scalability.

II. Driving agents and top specialists (e.g., Kone, Valmet, Nokia, Bittium)
Companies in this category are major players and top specialists in their own industry. They have integrated software into their business, making it a key element of innovation and added value. All sectors include such companies, ranging from software firms to machine manufacturers. Companies of this type should aim at notable growth (e.g., an annual 10%), as well as at improving user experience and quality with the help of software. Companies in this category also operate on the global market, in their own field of speciality. Companies selling software licences in their own niche field can also be analysed in this category.
III. Production of high-quality digital services (e.g., Reaktor, Gofore, Siili Solutions, Solita, Vincit, Kela, Tax Administration, OP, Population Register Centre)

Organisations in this category produce and provide digital services that meet the needs of, for example, administration, trade and financing. The demand for such services continues to increase, and new ways to provide digital services continue to emerge. We must therefore clearly enhance the productivity, agility and experimental nature of software development to ensure that the resulting services are productive, innovative, usable and efficient. All significant public and private services are expected to become digital and software-based. These services will generate new, major software exports, and Finland can be a pioneer in this field.

IV. Development and maintenance of operational activities (e.g., Telia, Apotti, CGII)

Companies in this category provide cost-effective development and maintenance services for software, information systems and IT infrastructure. They therefore have an important impact on the productivity and quality of software development. The development and maintenance activities carried out by these companies should work seamlessly, based on the DevOps philosophy, with customer business. The goal should be to achieve as highly automated methods as possible for the development and maintenance of software and information systems.

3.1.2 The major problems related to software in the future

Most experts mention the continued shortage of skilled workforce as one of the main problems. However, this cannot be alleviated merely by providing a greater volume of specifically targeted education. What is also needed is greater efficiency and productivity in software engineering. Research plays a key role in this respect. As a solution, one of the interviewees suggested that Finland should also exploit international competence and help foreign students studying software engineering at Finnish universities find a place in Finnish society and employment in Finnish companies. At present, foreign graduates seem to be quickly ousted from Finland if they do not immediately find employment after graduation.

Conventional procedures also involve major challenges. Traditional industry follows accustomed procedures, which do not consider software as a source of innovation and added value. There is a risk of misunderstanding potential. For example, development may focus on artificial intelligence instead of making basic systems and software into high-quality, efficient and useful sources of added
value. Problems may also emerge in leadership. Since the volume and significance of software and software-related work are not well understood outside the software industry, software is not seen to be a strategic part of business or of product and service development.

Most Finnish software companies work on commission instead of focusing on developing products. There may be limited understanding and opportunities to create scalable business models for software-intensive services. Capital, funding and risk-taking ability may also be lacking. Moreover, the operating model adopted by the public sector, in particular, in which the client gains full ownership of IPR, may make it more difficult to transfer to product-based business.

The Finnish research and innovation system does not consider software to be a research area in its own right, which leads to a decline in relevant university research. This has been a significant problem in software-related research and education in recent years. Take the former Tampere University of Technology for example, which had as many as six professors in software engineering in its best years. These days the University has one professor and one associate professor in the field.

### 3.1.3 Import and export outlook for software

Finland is most likely a net importer of software due to the global nature of services (such as Google and operating systems) that have an established infrastructure. Companies can, however, find their own niche in areas such as games, IoT, embedded systems and cloud-based systems. Nevertheless, it is impossible to achieve a competitive edge solely by applying foreign off-the-shelf software in, for example, industrial robotics or health technology. What we need is the ability to study, assess, compare and improve software-internal technological solutions and alternatives. It is also of concern that software start-ups are usually sold to foreign investors early in their growth stage. Is Finnish economic growth and expertise being sold cheaply to other countries?

### 3.2 The position and present state of software in Finland

#### 3.2.1 Strengths in business

One of the interviewees described internationally successful software business areas as being isolated and narrow. Telecommunications software, information security software, games, entertainment and smart locks were pinpointed as strong areas. The Industrial Internet of Things offers a great deal of potential, especially regarding software-based business involving mechanical product innovations. Active efforts are needed to maintain present strengths in the future. It is also important to identify new drivers. The start-up culture plays
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an important part in this respect, but for each success we will most likely need hundreds of failures.

3.2.2 Strengths in research
According to the interviewees, the research and education system has brought structured expertise into software development. Integrated production models exist, for example in agile methods and DevOps. In recent years, Finnish universities have had a strong presence at international conferences in the field of empirical software engineering, which aims to improve aspects such as productivity, quality and innovation in real environments. Finnish research has also had a visible role in experimental software development and in promoting a culture that supports such development. In line with this approach, the goal is to create brand new solutions enabled by software. There is an ever greater and broader need for experimental approaches also in practical product and service development. However, there is not enough funding for research aiming to develop new ways to enhance software engineering.

3.2.3 Strengths in the public sector
Strengths were also identified in public-sector software. For example, the services of the Finnish tax administration and the digitalisation of administration are of a high quality. Public investments may also support international competition in other areas. However, the public sector often requests ownership of all rights to the content. This means that service production does not result in reusable product models that could also be sold in other contexts.

3.2.4 Strong ecosystems and collaboration
A few examples of strong software ecosystems were mentioned. The financial management systems of Netvisor (Visma) and Procountor are important ecosystems for SMEs, replacing a considerable – and increasing – amount of manual work. The banking sector has also been a prominent software-related ecosystem, which now, however, is threatened by international competition, especially at the EU level. The Industrial Internet of Things offers new opportunities, but it also calls for cooperation and alliances. Finnish resources do not bear comparison to the resources that major US companies can tap into in the production of software products and services for various sectors, such as healthcare. To improve domestic competitiveness, we need more cooperation between businesses in order to identify competence areas as well as to innovatively apply and produce open-source components. Finland is also well positioned in information security and embedded software.
3.2.5 Area of development: leadership and breaking down myths in the software industry

In industrial companies, the company management often has a background in hardware and manufacture. This may be the reason for the traditional view of software being merely a compulsory component that makes products function. These days, software being an increasingly important generator of added value, it should be at the core of activities and form the basis for product design. Greater software competence is needed in company management. Moreover, urgent communication and marketing measures must be adopted to break persistent software-related myths. In Finland, Linda Liukas is a good example of ways to break myths about software. We need more such examples. The diversity of software engineering must also be taken into account in research. We should also turn our eyes outside Finland to learn new ideas about the coexistence of multidisciplinary software research and business.

3.2.6 Problem: lack of professionals and growth

In our material, the lack of professionals was mentioned time and again as the main problem related to software. What is more, the shortage of software professionals affects all industry, not only the software business. Due to the rapid growth of companies, corporate culture also comes under a new kind of pressure when companies reach a critical size. Self-organisation is sufficient in the early stages, but at a certain growth stage, attention must be focused on management and the methods used to control quality and productivity. Many companies spend a great deal of time and resources on testing and deploying new analytics tools and automation. This could also be done in cooperation with educational institutions. As mentioned, one way to combat the lack of professionals is to turn to international competence and especially to ensure flexible practices in Finnish universities to encourage foreign students studying at Finnish universities to stay in the country.

3.2.7 Research needs in software engineering

The research needs mentioned by the interviewees were decidedly production-oriented, including, for example, the development of automated software engineering. In the interviewees’ opinion, software-related equipment, tools and automated processes are important topics of research and development. The goal of such research should be to improve productivity and boost innovativeness. Experimentation, as well as the methods, tools and automation enabling it form another key research area according to the interviewees. Service design, user-orientation and software frameworks were also mentioned in this context.
3.2.8 Education, employment and continuous learning

The acute shortage of professionals also came up in connection with educational needs. The Finnish education policy was generally considered to be short-sighted and to offer a poor match to the sector’s needs. Other aspects mentioned in this context included the improvement of job rotation to prevent skills from becoming outdated, as well as the importance of continuing professional education, retraining and conversion training to create paths to new duties. Identifying the competence of younger students as well as supporting and encouraging them to complete a degree, find employment or set up a company were also found to be necessary tasks.

3.2.9 Opinions on the funding of research and development

Generally speaking, the Finnish innovation policy was found to be problematic. One of the interviewees characterised the funding provided by Business Finland to be biased because it is solely based on radical innovations. These, however, are impossible to achieve without productive software development. Business-led projects, in turn, were considered to be short-sighted, since they make it difficult to commit to development spanning several years. One of the interviewees also found the Academy of Finland’s approach to be questionable since the Academy does not have a specific funding category for software. According to one of the interviewees, greater focus should be placed on software investments. Software research would greatly benefit Finnish industry overall. Support offered to individual technology innovations can only help individual companies, not entire sectors. The slump in public research funding has led to the volume of software research declining in Finland. According to the director interviewed, funding for software research should be quadrupled from the present amount. Another interviewee pointed out that research and development in the sector have decreased catastrophically. This, said the interviewee, may have harmful effects. While software enables an important leap in development in all industrial sectors, uncontrolled and incompetent management of software engineering can quickly undermine the market position of companies. According to the interviewee, the software industry should be treated as a national strategic opportunity; a sector with a high degree of processing that requires advanced skills and competence. In the interviewee’s opinion, industrial businesses conceal the significance of software engineering by using the hype concept of digitalisation, making the size of the required change difficult to perceive – much less manage and lead.
3.2.10 The required administrative and legislative measures

The shortage of professionals also came up in the answers to our question about necessary administrative and legislative measures. Many respondents expressed the need for more basic education in software engineering at universities and in other educational institutions. Coordination between different forms of education and the elimination of educational dead-ends were also considered to be important (e.g., DEFA – Digital Education for All, Hive coding school, the Open University). Moreover, awareness and understanding of software engineering should be boosted “from daycare to university admissions”. The inadequate competence and software-related attitudes of teachers, especially those teaching children, were also mentioned as a big problem.

The need for support for early-stage companies, which Business Finland, among others, could provide was also brought up.
Measures for developing the software industry
As described in the previous chapter, the software industry is not a homogeneous sector. Software is omnipresent in society and found in homes as well as in business and industry. Software is used to perform various tasks, and the skills and competence required in software development therefore vary considerably. For example, the competence needed in administrative IT differs from that needed in automotive software development. Because of this, we will present a set of measures that target either a) software and the software industry as a whole or b) the previously described individual software business categories.

The measures discussed in this report primarily focus on the improvement of productivity, quality and growth. These require a national software strategy to be drawn up and the research and education policy to be improved. We also propose a new development programme for the software industry, which would mirror the national software strategy, focusing on productivity and quality, the dissemination of software competence as well as the promotion of agility, user-orientation and a culture of experimentation. In addition to these general measures, we will also present more specific measures, which focus separately on the four software business categories discussed in the previous chapter.

4.1 Measures targeting the software industry as a whole

We propose four measures that focus generally on software and its development:

I. Creating a national software strategy at the government level.

Software products permeate all social activities, and success in their development is a necessary prerequisite for business. Nevertheless, software has not been approached from a strategic perspective in Finland. ICT research and development has mainly focused on radical innovations in special areas, such as mobile technologies and artificial intelligence. Software – the infrastructure and enabler of operations in general – has been pushed aside. Now is the time to examine the software industry from a strategic perspective and determine its research, development and education needs, its foreseeable future strengths and weaknesses, as well as the way to develop the software industry in the long term. The first task of such strategy work is to use scientific methods to generate an overview of the present state in Finland – a more detailed one than that provided in this report. Such work will involve collecting more comprehensive material either first-hand or with the help of cooperation partners (such as the Finnish Software and E-business Association or the Finnish Information Processing Association) and
conducting comparisons with other countries (such as Sweden and Germany).

2. Placing software matters under a single ministry.
Steered by several central government units, the digitalisation of society lacks an overall approach. For example, matters concerning cybersecurity are handled by several ministries and administrative branches (e.g., the Ministry of Finance, the Ministry of Social Affairs and Health, the Ministry of Defence, the Ministry of Transport and Communications). As regards software competence and business, other ministries (such as the Ministry of Education and Culture, the Ministry of Economic Affairs and Employment) are also involved. In view of the major shift in the software industry and its significance to Finnish society, the goal should be to provide more comprehensive steering through a single ministry, perhaps even by a separate ministry for software and digitalisation.

3. Making our research and education policy more far-sighted.
As a result of digitalisation, most activities are now coordinated and controlled with software. This means that any change in activities leads to some form of change and development in software. What is more, digitalisation continues to expand into new areas. We therefore believe that there will be a continued and growing need for software, which also means a continuous increase in competence needs. In view of this, our research and education policy must be far-sighted and take this growth outlook into account. The problem cannot be solved with short-term labour market training. What we need is a far-reaching approach to education and research focused on productivity as well as new and improved methods for software development.

4. A national development programme for the software industry based on the software strategy.
In connection with the preparation of a national software strategy, a development programme for the software industry, focused on productivity, competence and a culture of experimentation, should be launched immediately. It could target various levels of society, including business, the public sector and citizens. Such a programme could have three prongs, such as:

a. Improving the productivity and quality of software engineering.
Improved productivity and higher quality could help solve the shortage of professionals and improve the sector’s international competitiveness. This calls for a research and innovation programme that encompasses both long-term research and short-term business development.
b. Spreading software competence throughout society.

The focus in this prong would be on SMEs, the public sector and citizens. The goal would be to increase the understanding of software, the opportunities it provides and the significance of software to successful operations. Training programmes designed for different fields would be at the core of these activities.

c. Promoting agility, user-orientation and a culture of experimentation to boost digitalisation.

Modern online environments, in particular, require software that is continuously developed and maintained. Software also enables brand new solutions, the systemic impact and benefits of which cannot be fully discerned ahead of time. We therefore need agile, user-oriented and experimental approaches for building digital solutions. Systematic research, business development and education is required to engender such a culture of experimentation.

4.2 Measures targeting different categories of software business

In addition to the general measures discussed in the previous section, we also see a need for separate measures regarding different categories of software business. Although these measures focus on the special, individual needs of each category, participation in them should not be restricted to specific companies or business activities. The four categories that we discuss here are abstract groups used to facilitate planning and thinking. An individual company or other actor may well exhibit features from several categories and, in fact, benefit from the measures of several categories.

I. Scalable software export products (e.g., Supercell, F-Secure, M-Files)

a. Creating mechanisms for the strategic ownership of scalable software business in Finland

Scalable Finnish software businesses are typically sold to non-Finnish owners at an early stage of business. This is often not optimal for the success of Finland.

b. “Beyond coding” education and research, a comprehensive project for product oversight and governance, software business and the platform economy

A comprehensive national project should be created for scalable software business. It could comprise, for example, national Software Business MBA education jointly provided by different universities.
II. Driving agents and top specialists in their field (including all fields of industry, e.g., Kone, Valmet, Nokia, Bittium)

a. A research and development programme for systematically improving the software engineering methods, culture and competence of companies other than traditional software firms

Traditional industrial companies are extremely competent in the development and manufacture of their conventional products. However, they may be on a less firm footing in software development and may have outsourced such development to third parties. With new added value mainly being produced with software, there is also a greater need to have full command over one’s software. This research and development programme would focus especially on generating productive, high-quality software development for the manufacturing industry.

b. Software engineering training outside software education proper

Digitalisation creates the need to manage and understand software development in all industrial sectors. To cater to these needs, software engineering education should also be promoted in sectors other than ICT.

c. A project to support the integration of new technologies and methods (e.g., IoT, AI) into software-intensive products and services

Much of ongoing research into artificial intelligence and data science is basic research. To broadly deploy applications based on new technologies and methods and to integrate them into products and services, we must also take into account the perspective of software engineering to ensure an adequate level of usability, reliability, safety, productivity and maintainability.

III. Production of high-quality digital services (e.g., Reaktor, Gofore, Solita, Vincit, Kela, Tax Administration, Population Register Centre, OP)

a. “Beyond coding” education and research, a comprehensive project for product oversight and governance, software business and the platform economy (e.g., a national Software Business MBA)

The “beyond coding” project discussed above would also be suitable for the production of high-quality digital services.

b. Investing in education and supervision focused on user-orientation and service design

The importance of user-orientation and service design was emphasised in the interviews. Investments must be made in education. In addition, these matters could be promoted by creating a post for an ombudsman in charge of digital usa-
bility, who would be accountable to the Consumer Ombudsman.

c. Improving the ability of public administration to procure systems, for example from Finnish cooperation networks instead of from a single supplier

Finnish small- and medium-sized software companies are innovative and growth-oriented. Public administration could promote their growth by developing its own competence and operating models that would enable system acquisitions from cooperation networks instead of from large, well-established system suppliers. The alliance model could be applied in this context.

d. Promoting legislation and practices that support the reuse of services designed for the public sector in other contexts

Finnish software businesses could retain the rights to the solutions and properties of systems they develop for public administration. This could pave the way for product-based scalable business operations in applicable contexts.

e. Setting up a programme for improving productivity in the production and use of digital services

In our interviews, the shortage of competent workforce and professionals was mentioned repeatedly as the most urgent problem. Since the need for software continues to increase, we do not believe this problem can be solved solely by providing more education. Productivity also needs to improve considerably, and the best way to achieve this is by creating a research and development programme to answer the challenge.

I. Development and maintenance of operational activities (e.g., Telia, Apotti, CGI)

a. Conducting a survey of strategic national software platforms and cloud services and drawing up policies for their ownership and development

Instead of automatically adopting software platforms and cloud services provided by US companies, a diligent strategic survey should be conducted and a plan drawn up regarding the utilisation of platforms and cloud services. The survey should determine which services can originate from the US, which from Europe and which ought to be national. Such a survey might also provide opportunities for the emergence of new national platforms.

b. Supporting EU policies in the global development of information security and privacy

Radical measures should be avoided and Finland should be kept an attractive place for IT service investments.

c. Setting up continuing and further education to improve the quality and productivity of IT tasks in operational activities

Quality and productivity are also required in operational IT activities.
Conclusion
We began this report by stating that digitalisation makes all business at least partly software business. Most new innovations and added value are created with the help of software, and the platform economy is also dependent on software. As digitalisation pervades business, changes to business activities are also carried out with software. What is more, software is used to open, implement and accelerate most new markets.

For the purpose of this report, we examined key themes related to the software industry and their present state in Finland. We also interviewed ten company directors. This work also involved eight Finnish professors in software engineering.

We found that the ability to create and utilise software is key in nearly all successful business. However, software-related needs and the targets of research and development differ greatly depending on the type of operations. To facilitate our analysis, we opted to divide organisations into four categories based on their relationship with software. These included:

I. Scalable software export products
II. Driving agents and top specialists, including all fields of industry
III. Provision of high-quality digital services
IV. Development and maintenance of operational activities

Software is used for various tasks, which is why the skills and competence required for software development also vary accordingly. For example, the competence needed in administrative IT differs from that needed in automotive software development. We therefore proposed measures targeting a) software and the software industry as a whole and b) the individual software business categories employed in the report. Our measures focus on increasing the productivity, quality and growth of Finnish software business.

We proposed drawing up a national software strategy, improving the Finnish research and education policy and reorganising public administration from the perspective of digital solutions. We also suggested the creation of a general development programme for the software industry based on a national software strategy, which would focus on productivity and quality as well as on spreading software competence and on promoting agility, user-orientation and a culture of experimentation. Apart from these general measures, we also discussed more specific measures targeting each of the four software business categories separately.

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