WHITEPAPER

DEVELOPING IOT IN PARTNERSHIPS

MAPPING CHALLENGES AND OPPORTUNITIES
IN THE DANISH IOT ECOSYSTEM

MAY 2020

Nordic IoT Centre
FOUNDED BY ALEXANDRA INSTITUTE AND FORCE TECHNOLOGY

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NORDIC IOT CENTRE

Nordic IoT Centre (NIoTC) promotes the usage and development of IoT in the Nordics by bringing together and engaging the relevant actors of the IoT ecosystem, and by enforcing Nordic values such as user focus, functional design, quality assurance and accountability in the development of IoT-enabled products and IoT-based services.

NIoTC's vision is to make the Nordics the best place in the world to use and develop IoT-enabled products and IoT-based services.

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This whitepaper is published with support from the Ministry of Higher Education and Science Denmark.

Ministry of Higher Education and Science Denmark

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1 INTRODUCTION

Internet of Things (IoT) provides society with great opportunities for optimization, efficiency and savings in industry and in public organizations, just as it offers new values and services for citizens, employees, businesses, and the public sector. Furthermore, the development of IoT is providing Danish companies with great new business opportunities. Technically almost everything is possible with IoT, and the Nordic region boasts many large companies and SMEs with all the competences needed to fulfil the many promises of IoT.

However, as this whitepaper shows, the companies still experience some substantial challenges for releasing the full potential of IoT. These challenges particularly concern issues around collaboration and partnership models, quality assurance, and not least good use-cases and business models for how to run IoT solutions in a way where all actors share responsibility and revenue.

This paper will present the initial results of an innovation project exploring the challenges and opportunities for developing and strengthening IoT ecosystems in the Nordic region. Based on interviews and workshops with relevant IoT stakeholders, the paper outlines nine specific challenges to release the full potential of IoT development in Denmark. The paper is the first of more papers exploring and developing new methods, tools and services for building IoT partnerships and business models with the aim of strengthening the Nordic IoT ecosystem.

2 SUMMARY OF FINDINGS

The research presented in this whitepaper is based on qualitative research – two stakeholder workshops and 11 interviews – conducted among IoT developers. The analysis reveals nine main challenges and related needs in order to ensure a flourishing IoT development in the Nordic region. Below is a short summary of these challenges and needs:

1. **Make it real:** For a long time, IoT has been surrounded by hype, hopes and fear, and most projects have been pilot projects showing the potentials of IoT. Now there is an urgent need to demonstrate and showcase real-life IoT projects which have been implemented and show a sustainable IoT business case. There is a need for educating the public, clients and especially CEOs in the companies and organizations that should implement IoT solutions on exactly what IoT is, what it can do for them, and how it may develop their business strategy. Furthermore, there is a need to engage the industry associations in the IoT agenda.
2. **Problem of plenty – need for actor mapping:** it is a huge problem that the IoT ecosystem is very fragmented as this makes it difficult for clients who want to build and implement an IoT system to get started and to navigate in the field. There is a need for an actor mapping, which makes it easy for clients to find the needed actors throughout the value chain. There is a need for independent and technology agnostic advisors who can work as business-to-technology-interpreters and guide potential clients on how to get started.
3. **From technology-driven to user needs-driven approaches to IoT:** Until now, IoT development has been mainly technology-driven, which has resulted in many IoT systems that may work technically but do not solve anyone's actual needs and thus do not provide value to the end user. There is now a need for shifting focus to a more challenge-, business- and needs-driven approach. Thus, there is a need for services and tools that can analyze and visualize actual user needs and value creation for the end user.
4. **Matchmaking:** In order to ensure a shift from a technology-driven to a challenge-driven approach, there is a need for matching the supply and the demand side. There is a need for a marketplace where the clients, who have real-life challenges to solve, can post their problems and needs and thereby meet the developers who can help solve these through IoT.
5. **Collaboration, partnerships and trust:** IoT systems challenges the ordinary value chain of contractor and subsuppliers. Instead IoT systems are often demanding much more complex partnership setups. However, in order for such new partnership models to succeed, there is a need for a new code of conduct that provides shared guiding principles for doing IoT projects, which both ensure the responsibility and benefits of all partners and

provide safe, solid, and good solutions. We believe the Nordic region to be uniform enough and ready enough to be the right size for sharing this “Nordic code of conduct”.

6. **Business models:** there is a lack of proven business cases and business models that work across the value chain as a major challenge. There is a need for business models that ensure that each part in the value chain receives a fair share of the generated profit, proportionally to its investment, role, importance and/or value addition to the final service or product.
7. **Interoperability:** the IoT market is challenged by the many different standards, protocols and platforms, which are often proprietary and make it difficult for customers to pick and choose the best solutions for their challenges without either being locked to one technology or having to deal with many different systems not collaborating. The lack of interoperability generates a risk of creating a fragmented IoT market developed in silos. Thus, there is a need for creating a generalized framework for interoperability, which can support collaboration across products, applications, and services and preclude vendor lock-in.
8. **Standards and policy:** The IoT marked is developing fast and many new standards and regulations are on their way, both nationally and internationally. It is a big challenge for IoT developers and customers to keep up to date with these. Therefore, there is a need for an independent actor who can keep up to date with the policy and standardization work and who can translate this into a Nordic context.
9. **Knowledge sharing:** A lot of time and money are wasted because many actors are testing the same technologies and set-ups independently instead of learning from each other’s tests, experience, and knowledge. There is a need for better sharing of knowledge and experience across the different actors, silos and countries in the Nordic region. There is a need for ‘safe spaces’ where difficult issues and problems can be discussed in confidence.

These nine challenges and needs will be further developed in section 4. But first a short introduction to the research project behind the findings.

3 THE RESEARCH PROJECT

This whitepaper is written as part of a research project about IoT Ecosystems in the Nordic region. The project is run by the Nordic IoT Centre[1], which is a joint collaboration between Force Technology[2] and the Alexandra Institute[3]. The two institutions are part of the seven Danish government-approved Research and Technology Organizations (RTO)[4]. The RTOs play a key role in the Danish innovation system by connecting technology and businesses in order to ensure that Danish research and innovation is made accesible and employable for Danish SME's (small and medium-sized enterprises). An important task for the RTOs is to provide neutral and independent guidance to companies and organizations, thereby ensuring better and more efficient use of new research and technology. FORCE Technology is specialized in hardware while the Alexandra Institute are experts in software. This present research project is a two-year project funded by the Danish Ministry of Higher Education and Science as part of the RTO funding program *Bedre Innovation*[5].

3.1 THE NORDIC IOT CENTRE

The vision of the Nordic IoT Centre is to make the Nordic region the best place to develop IoT products, services and systems. We will do this by strengthening the IoT ecosystem – that is the collaboration of IoT developers (hardware and software suppliers), IoT experts/consultants, and the end customer, who defines the needs and has the domain-specific knowledge. An important part of the ecosystem is the universities and knowledge institutions who contribute knowledge, facilities, and an international focus. Together these partners constitute a value-creating ecosystem for IoT development.

[1] *Nordic IoT Centre:* https://nordiciot.dk/
[2] *FORCE Technology:* https://forcetechnology.com/da
[3] *Alexandra Institute:* https://alexandra.dk/dk
[4] *GTS Institutterne* https://en.gts-net.dk/
[5] *Bedre Innovation:* http://www.bedreinnovation.dk/

THE NORDIC IOT CENTRE GIVES YOU ACCESS TO:

- the newest knowledge on technologies and standards within IoT
- highly skilled specialists in all aspects of successful IoT projects through our partners
- independent and technology agnostic guidance
- good examples of use cases
- knowledge about IoT business models
- invitations to relevant events and much more

The main purpose of the Nordic IoT Centre is to promote and advance the development and adoption of IoT in the Nordic countries. This is to be achieved by supporting the connection between those who wish to implement IoT solutions and those who develop and deliver the IoT solutions.

In order to investigate how the Nordic IoT Centre can best serve the existing IoT ecosystem, the first task for the present research project has been to make a qualitative study of the IoT stakeholders in order to get more insights into their challenges and needs. This whitepaper presents these findings. Before presenting the findings, the paper outlines the knowledge and market analysis which function as the basis for the research project.

3.2 INSIGHTS INTO THE IOT LANDSCAPE

IoT is one of the largest technological growth drivers on a global scale. McKinsey estimates a potential annual worldwide impact of between $ 3.9 and $ 11.1 trillion in 2025.[6] Accenture assesses, that Danish GDP has DKK 86 billion in growth potential until 2030, if the Danish industry increases its use of IoT solutions.[7] Particularly industrial companies in production, health/welfare, transport/logistics, the energy sector, retail, and the automotive industry are considered to have extraordinary digitalization potential. These industries together make up 35% of Danish private full-time employment.[8]

Denmark is a European pioneer in technological adoption, and IoT initiatives are emerging, especially in major Danish companies, with 60% having ongoing IoT initiatives in their business. However, the Nordic countries generally lag behind,

[6] *Unlocking the Potential of The Internet of Things, Report, McKinsey Global Institute, 2016*

[7] *How much can the industrial internet of things fast-track your economic growth? Accenture, 2015*

[8] *Forbundne muligheder Analyse af danske virksomheders brug af Internet of Things, Iris Group, 2016*

for example, the United States.[9] This is due to the following challenges uncovered in studies from DI[10], BCG[11], and Iris Group[12]:

1) Few companies have the knowledge and organizational resources to uncover all aspects of an IoT solution
2) IoT should be approached as the design of a whole system but is often addressed by initiating segmented development projects
3) Expectation of IoT implementation being costly holds companies back
4) Inability to identify the value in the total value chain using IoT
5) Organizational challenges as IoT challenges existing governance structures
6) Lack of knowledge in the top management layers around IoT and its potential

The publication *FORSK2025 – fremtidens løfterige forskningsområde* (Danish Ministry of Higher Education and Science) highlights a need for doing research throughout the entire IoT value chain, including knowledge of embedded systems, wireless communication, network design, and scalability[13]. In addition, there is a need for scalable methods, tools and techniques that support the development of systems with regard to rapid and affordable development of products. Furthermore, it is a challenge that many of the IoT systems requested from the market, such as large smart city IoT systems, demand new ways of collaboration and partnerships between several companies and between private and public actors. Such partnerships challenge the way most companies work, as they are used to developing the whole system themselves. This calls for new methods and new tools.

In order to strengthen the Nordic IoT ecosystem, there are three particular target groups that are important to focus on:

1) **Specialists in the development of IoT systems and devices**

   The industry consists of approximately 3,200 companies with more than two employees.

[9] Bigger, Bolder, and Faster: The Digital Agenda for Nordic Companies, Boston Consulting Group, 2017

[10] Every. Thing. Connected, Ericsson, Deloitte Monitor og Dansk Industri, 2015

[11] Bigger, Bolder, and Faster: The Digital Agenda for Nordic Companies, Boston Consulting Group, 2017

[12] Forbundne muligheder Analyse af danske virksomheders brug af Internet of Things, Iris Group, 2016

[13] FORSK2025 – fremtidens løfterige forskningsområde, Styrelsen for Forskning og Uddannelse, 2017

Challenge: IoT is the Wild West today. Systems are chosen or deselected on the basis of unit price and smart features but without real assurance that the underlying technology is implemented correctly and thus works properly.

2) **SMEs in the mechatronics industry that want to digitize using IoT**

The industry consists of approximately 6,000 companies with more than two employees.
Challenge: IoT is based on the fact that data from sensors is collected and sold, and by pairing information, it allows for the development of new services. Businesses today do not know which sensors to integrate, and therefore they must be able to look up sensors and sensor systems in a directory to check their IoT parameters. At the same time, they need to be able to find partners for their development process. This is an essential target group as they stand to develop most IoT products.

3) **Businesses and public actors to roll out IoT systems**

This is an extremely broad industry which spreads across many sub-industries. The industry is estimated at around 8,500 companies, of which about 300 are large companies.

Challenge**:** Municipalities, distribution, energy, transport and facility management companies are already rolling out IoT systems with more than 1,000 units. At the same time, they are also responsible for the selection and operation of the radio network to handle the entire communication and cloud platforms for data processing. If errors are made at this stage, it can have very large functional, financial, and safety consequences. It is essential that they be equipped with skills in the field to minimize uncertainty about the business case and to qualify the digital skills.[14] Large operators with 1,000+ IoT devices connected to their system must be able to rely on the stability and functionality of the devices. There are huge costs for the system owner whose parts need to be replaced if technicians have to be called out or maybe even make system breakdowns, or the citizen has to be home. Unit cost is often the least cost but the source of problems. The goal is that staff will primarily be used for setup and testing.

The current IoT market is characterized by a situation where developers are often bidding on the whole end-to-end solution and therefore will have to develop parts of the system from scratch, as two projects are rarely the same, or they might not own all the needed layers. By having a broader knowledge of the strengths and competences of others, it will be possible to draw on these skills,

[14] Strategi for Danmarks digitale vækst, Erhvervsministeriet, januar 2018 – page 30

thereby avoiding parallel development in several companies simultaneously. This will pave the way for a deeper specialization of the individual companies, and simultaneously the IoT market as a whole will develop faster. This development cannot be expected to be initiated by private actors as there is a need for an independent party to facilitate this effort. The market does not develop the needed kinds of services, as the companies that currently provide services and technology for the development of IoT systems are primarily focused on their own domain knowledge or provide non-independent advice. Today, it is not possible to find supplier-independent screening and counseling services, because such services cannot (unlike stand-alone services) provide critical economic income. Thus, service and technology providers cannot be expected to act unbiased and technology agnostic towards their existing or potential customers.

In Denmark there is a multitude of communication systems that provide connectivity to IoT devices, such as SigFox, LoRaWAN, NB IoT, 2G, 3G, Wi-Fi, Bluetooth etc. – that compete aboto become the leading standard for developing IoT solutions. Most IoT developers associate, one way or the other, with one of these standards and/or, at a higher layer, with one of the leading data analytics platforms, such as Microsoft Azure, Oracle Internet of Things Cloud, Google Cloud IoT Core, and AWS IoT Analytics. Therefore, one cannot expect the developers to deliver independent advice on which technology or platform is the best for a specific use case. However, this is one of the biggest challenges for clients wanting to get started with IoT: to make sure that they pick the right IoT architecture for their use case and requirement specification – from the beginning.

One of the major challenges of developing IoT through partnerships is trust among users and businesses. This includes trusting that your personal data will be treated confidentially; that the sensor being used provides correct data; that the network can deliver data reliably and warn if it starts to fail. At the same time, it is essential that it is possible to find the fault in the network when it has gone wrong and that the sensors that are difficult to access, for example deep in a well or are cast into cement, also function in five and 15 years. This trust becomes especially difficult and relevant when a consortium of several parties has been involved in the development. In order to strengthen the Nordic IoT ecosystem, there is therefore a need for new services and initiatives that can make it easier to build partnerships and mobilize trust.

Based on the more general challenges listed above, the present research project aims at furthering the understanding of the challenges and the needs as presented by relevant IoT stakeholders.

3.3 THE RESEARCH AND INFORMANTS

The present whitepaper outlines the results of the first year of work in the research project *Ecosystems for IoT Development and Test in Denmark*[15]. The first year has been dedicated to establishing a close relation to the target group and to get a more nuanced view of their challenges and particular needs.

The fieldwork, which will be presented below, builds upon two stakeholder workshops and 11 interviews. Besides that, meetings and discussions with the Advisory Board and the partners[16] of the Nordic IoT Centre have been valuable in getting insights into the issues at stake and to get access to the relevant informants. Furthermore, participation in national and international events and conferences has been valuable in understanding the statements from the informants in a bigger picture.

We conducted two stakeholder workshops[17], one in Copenhagen and one in Aarhus. The purpose was to generate a safe space for discussing the challenges of developing IoT in partnerships. Around 30 companies and representatives from universities participated. Based on the insights from the stakeholder workshops, we mapped relevant issues and developed a questionnaire for the interviews (see appendix). The 11 interviewees consist of one research and policy expert from a Danish university, 8 companies (both SMEs and large companies), one municipality, and one representative from an international IoT cluster with a purpose similar to the Nordic IoT Centre.

We have kept the identity of the informants anonymous because we wanted the conversations to be as honest as possible and because we want to present some general challenges and observation across the field of IoT actors, rather than the opinions of particular stakeholders. The informants will be referenced through the size of the company and their specialization.

In this part of the research we have focused mostly on the developers and network providers. However, based on one of the findings – that IoT development needs to focus more on the customers and the demand side – we will in the future go more in depth with the challenges and needs of the businesses and public actors who are to roll out IoT systems.

In the following section we present the results of our analysis.

[15] *http://www.bedreinnovation.dk/%C3%B8kosystem-iot-udvikling-og-test-i-danmark*

[16] *https://nordiciot.dk/partners/*

[17] *https://infinit.dk/iot/stakeholdernetvaerk-for-det-nordiske-iot-oekosystem-koebenhavn/*

4 CHALLENGES AND NEEDS OF DEVELOPING IOT IN PARTNERSHIPS

In this section we will present the potentials and challenges that we analyzed based of the two stakeholder workshops and the 11 interviews. Each challenge will lead to a number of needs, which will provide the foundation for our further work and activities towards strengthening the development of IoT in the Nordic region. The first section outlines why and how the stakeholders see a great potential in developing IoT in partnerships. Then we describe each of the nine challenges still to be solved in order to fulfil the great potentials of IoT.

Among the informants there is a unanimous agreement that there are many valuable potentials in working in partnerships. Most agree that as long as the IoT market is growing in the Nordic region, they will also individually benefit from this growth.

> ***"It is impossible to develop everything yourself. This is not a disadvantage, but it does make it quite difficult!"***
> *(Large international company, software and hardware developer)*

Both the bigger and the smaller companies said that they cannot develop IoT alone but need partners with specific competences. In order to make the best possible solutions, we need companies and experts who are specialized in very particular bits of the IoT architecture. Suppliers need to specialize in order to become the best in doing what they are doing. One of the stakeholders point out that in order to have the time and energy to be innovative, it is important that you specialize rather than try to be good at everything. Even the big companies cannot be the best in all the different aspects of IoT, but instead companies need to be well-connected in order to always find the best competences and the components needed in order to put together the best possible IoT solution. For the bigger companies it is merely a matter of having access to the new innovative competences which exist in the start-up and SME market. Partnering up with small companies also provides the big companies with the opportunity to evaluate which ones they want to invest in or buy.

For smaller companies the benefit of working in partnerships is mainly that they become more agile and can quickly find the right partners in order to set a good team who can satisfy the needs of customers and thereby possibly compete with some of the major companies. When working in partnerships, which are flexible and where competences, components and partners can be replaced depending

on the specific assignment, the small companies can act faster and deliver competitive IoT solutions. Many of the stakeholders mention that one of the main benefits of being well-connected and working in partnerships is that you can reduce time-to-market because you can quickly find the needed components and competences.

Another positive effect mentioned by many stakeholders is the sharing of risks and responsibilities in IoT partnerships. When developing a whole end-to-end solution there are many critical issues in terms of stability and quality that need to be addressed; the quality and reliability of the sensors, the network, the handling of data in terms of privacy and security, the processing and translation of data, and not least the interface through which the system is presented to the end-user. Working in partnerships can delegate and share the responsibility. As a smaller software developer company explains:

> ***"Normally, we engage in partnerships with a network provider, a company delivering sensors and us taking care of software. Often, in our IoT solutions, the sensors need to be buried in the ground or installed in very difficult and expensive places. Then it is really nice if we have made a partnership with the sensor company ensuring that they are responsible for the reliability of the sensors."***
> *(Interview: Small software developer)*

An academic scholar describes this new way of doing innovation through Martin Curley's concept of Open Innovation 2.0.

> ***"It is easier to develop the whole IoT system in-house, however the problem is that it will never be as good as if you open up your innovation process, inviting partners and doing Open Innovation 2.0."***
> *(IoT Academic Scholar)*

This new paradigm, as Curley calls it, calls for new ways of doing innovation in the time of digitization:

> ***"Open Innovation 2.O (OI2) is a new paradigm based on principles of integrated collaboration, co-created shared value, cultivated innovation ecosystems, unleashed exponential technologies, and extraordinarily rapid adoption. We believe that innovation can be a discipline practiced by many, rather than an art mastered by few."***
> *(Martin Curley and Bror Salmelin 2013)*

However, such new ways of doing innovation do not only provide great new opportunities for businesses, they also provide new challenges and problems. It is

exactly some of these issues we will be dealing with in this whitepaper and in our further work in the project.

Though all the stakeholders in our research agree that working in partnerships is a very good idea, they also all agree that there are still many challenges to overcome in building and maintaining good partnerships.

4.1 MAKE IT REAL

A general problem that most of the informants mention is that IoT has been surrounded by lots of hype, hopes and fears for a very long time. This has made it really difficult for software and hardware developers who work on very concrete solutions because the costumers do not really have realistic insights into or an overview of *what IoT actually can do – what specific problems and needs it can solve*! The informants at one of the stakeholder workshops explain this by a long period of time where the development of technology has been the primary focus, rather than a focus on use cases and business models. Now there is a need to get away from the hype and instead visualize and communicate *what IoT is* and *what it can do*. We need to focus more on functionality and value creation.

There is a need to spread the word and educate both potential customers, such as municipalities and corporations, and also the general public, about IoT and its many possibilities. So far, it has been difficult to reach the CEOs and management level. CEOs lack sufficient knowledge about IoT in order to make informed decisions. They often feel insecure about how IoT can and should be employed in the organization. Either this leads to a lack of investment or the decisions are pushed to the operational part of the organization. However, to unlock the value of IoT, it has to be prioritized by top management. Thus, initiatives are needed to inform and engage the top management to embrace the IoT development. Besides CEOs, the informants also mention industry associations, such as *Dansk Metal* and *Dansk Energi*, as important actors to get engaged in the IoT agenda.

Partly related to this issue is the so-called *pilot sickness*. A lot of pilot projects have been conducted. There is a need to focus much more on the implementation process in a real-life setting. Who should operate the systems in the long run? Who are the customers, how do we maintain them, and what long-term value do they achieve? Who can make money on the system and how? In order to resolve these challenges, we need to involve companies who are interested in operating the solutions in partnerships from the beginning of the development process.

NEEDS

- Use cases illustrating what IoT is and can
- Education of the public and of clients
- Initiatives to engage CEOs and management
- Engagement of industry associations

4.2 PROBLEM OF PLENTY – NEED FOR ACTOR MAPPING

Many of the informants mention that it is a huge problem that the IoT ecosystem is very fragmented. This makes it very difficult for clients who want to build and implement an IoT system to get started and to navigate in the field.

> ***"Right now, there is a problem of plenty in the market. There are so many actors offering different solutions, but the customers and clients, and even ourselves, lack an overview of all the actors and what they can offer to which part of a technical setup."***
> *(Interview: Small software developer)*

There is an outspoken need for an independent actor mapping where potential clients who want to build an IoT solution can get an overview of which actors, competences and suppliers are available for specific functionalities of the system. Alongside the mapping of actors, there is a need for independent and technology agnostic advisors who can help clients to navigate in the actor landscape and understand the different parts and components needed to create a reliable system, which serves the needs of the users. The advisor role should be that of a business-to-technology-interpreter who can help translate clients problems into specific technology needs; help clarify the value stream through potential actors and technologies. The advisor should provide the necessary information about different networks, standards, and protocols for the clients to make decisions on an informed basis.

"I need to know what exists on the market. Right now, so much is going on with IoT, but it feels quite random what we as clients get access to. You happen to meet technology providers at a fair or conference and then you go with their solution without knowing what else exists out there."

(Interview: smart city representative for a municipality)

It is important that the clients are able to find all the different actors to fulfil the entire value chain in the system. The actors mentioned as important to present in the ecosystem is:

- Accelerators and incubators
- Investors
- Startups
- Business-to-technology interpreters
- Business developers
- Recruitment agencies for front office consultancy
- Quality assurance specialists
- Specialists from process industry
- Domain-specific knowledge
- International collaboration
- Hardware developers
- Infrastructure owners
- Municipalities
- Politicians
- Large corporations
- EVERYONE I don't know I need yet!

NEEDS

- Actor mapping
- Independent and technology agnostic advising and guiding
- Business-to-technology-interpreters
- Help to get started

4.3 FROM TECHNOLOGY-DRIVEN TO USER NEEDS-DRIVEN APPROACHES TO IOT

In unison the informants – both the interviewees and the participants in the stakeholder workshops – agree that the IoT development so far has been mainly technology-driven; a matter of finding out what is technologically possible and how. This has resulted in many IoT systems that may work technically but do not solve anyone's actual needs and thus do not provide value to the end user.

> ***"We have the technology relatively well sorted out – now we need to change approach and start focusing on what the customers need, and we need to take out point of departure in the good business case."***
>
> *(Stakeholder workshop, utility company)*

One of the most urgent needs in the Nordic IoT development is thus a shift of focus from a technology-driven to a more challenge- and business-driven approach. This shift is, as a representative from a municipality confirms, also about to happen in the municipalities, who are paying more attention to the problems needed to be solved, rather than starting from a technology fascination.

Whereas all stakeholders involved seem to agree that the development process needs to start with the good business case, spotting and developing good business cases seem more difficult. Several informants flag the challenge that it is often difficult to ensure and evaluate the good business case in advance of a development project. It is important to be able to show and visualize the actual value of the system. Value can come in many different shapes – not only direct economic benefit. One of the informants says that the IoT sector should learn from the experiences of the digitization process,where there has been a huge focus on savings and efficiency, which has party resulted in a certain scepticism among the employees in the organizations undergoing a digitization process, because it has too often been the purpose to make some employees redundant. It is important to focus on other kinds of value creation than efficiency and savings when developing IoT. This could be productivity, welfare, and better employee conditions. We need to integrate the entire value chain.

However, taking a challenge-driven approach also puts pressure on the customers. The informants point out that their clients often are quite cautious about revealing their challenges and pain points. They are afraid to reveal business ideas and secrets. Thus, there is a job to be done educating companies and especially CEOs to be more transparent in their collaboration with developers and more open and willing to explain their pain points. This could be dealt with through an independent entity who can help facilitate the process of specifying pain points, challenges, mindset and performance specification – and to help set the consortium of partners to solve the challenge and design the solution.

There is an overall need for approaching IoT as a meeting between supply and demand – between challenge and solution.

NEEDS

- Initiatives to identify and visualize the challenges of future customers/market
- Service to help clients identify and describe challenges
- Showcase of good business cases
- Tools for identifying and visualizing value creation
- Events for matching supply and demand
- Tools for creating security and confidence between developer and customer

4.4 MATCHMAKING

A majority of the informants formulated a need for more strategic and structured matchmaking services. Potential clients need to meet the developers. Developers need a showcasing platform for getting their products out to customers. Developers need to meet other subsuppliers or partners who can solve specific needs and close the gaps.

"It would be nice to have a platform for getting in contact with new subsuppliers of software competences, which we could use to make our solutions even better."
(Interview: small software and hardware developer).

Municipalities, organizations and companies who have IoT-related challenges to solve need at platform for exposing their challenges to the suppliers who can design the solutions. Last but not least, such a platform could also gather and expose all the different challenges and competitions such as Accelerace, CBS Growth, DTU Tech Challenge, the EIT Climate-KIC's global CleanTech Competition, and the IoT-related competitions organized by universities.

One of the informants even mentioned that it would be nice to have an idea marketplace where one could propose good ideas for systems or solutions one would like to be a part of without having to take the lead.

Many of the informants also mentioned the need for continuous informal networking. There are a lot of IoT-related networking events. However, there is a

need for a 'safe space' where stakeholders can meet to discuss common challenges and potential answers.

"We are starting to see companies hiring consultants to help them find the right collaborators."
(Interview: software and hardware developer)

With reference to section 4.2 (problem of plenty – need for actor mapping), matchmaking initiatives should involve independent and technology agnostic advisors who can help clients find the right developers and partners to collaborate with.

NEEDS

- Matchmaking initiatives and 'safe spaces' networking groups
- Market platform for solutions, challenges and competitions
- Independent advisors who can facilitate qualified and 'handheld' matchmaking

4.5 COLLABORATION, PARTNERSHIPS AND TRUST

IoT solutions often rely on a complex setup with many companies involved. Rather than having a generic business setup with a main contractor and a number of subsuppliers, the development shows that IoT systems are often better designed and run through more complex partnerships such as consortiums or PPPs (public-private partnerships).

"In the field of IoT, so many new things are happening concerning how one can and should be partners in a project. However, the way collaboration contracts are made is hopelessly old-fashioned – everyone wants to be the one with the contact to the end-user. In order to engage in a collaboration, it is important that chemistry is there and that both partners understand that they have to contribute to and earn money from the system."
(Interview: small hardware reseller and consultancy)

The informants agree that new partnership practices are needed. However, how to best configure partnerships and how to formalize the process is less obvious. We believe that this in one of the most urgent issues to deal with in order for the IoT development to flourish. In order to make good partnerships, it is crucial to

deal with issues around division of roles and responsibilities, issues of trust and commitment, transparency, ethics and new business models.

When developing collaboration models, the important part to focus on is the obligations of the individual partners and subcontractors. Many also highlight that it is an emerging model also seen in large corporations with different verticals. Another critical issue is to define who in a project should have access to which data, and who is allowed to do which parts of the data analytics. We hear all the time that data is gold, which means that having access to data becomes highly attractive. This is of course also a very critical issue for customers.

Many informants point to transparency as a critical issue. There is a problem of many companies wanting to white label the products as their own. Companies working in IoT need to become more transparent around who they are collaborating with and how. In order for the whole IoT market to flourish, it is important that it is transparent about which actors and components the different IoT solutions consist of. This will create a better understanding and ease further development – both for customers and developers.

However, a somewhat contradictory issue is also flagged by many informants, namely that it is important not to show too much of the complexity in the partnership to potential clients, who would often get nervous with a complex setup and division of responsibilities. It always seems easier to deal with *one* supplier and *one* product. Thus, when working with the development of new partnership models, it is important to deal with issues around what level of complexity is needed. How and when should the complexity be made visible and to whom? As several informants point out, it is important to have one company who is the main point of contact for the customer and who has the overall responsibility.

One of the missions of the Nordic IoT Centre is to make it easier and faster for SMEs to form consortiums, thereby enabling them to compete with the large companies who provide end-to-end solutions. One of the challenges to fast and easy formation of partnerships is the work around contractual models. As the informant in the quote above says, the existing contractual models are old-fashioned. Many of the small companies mention the pain of working with large companies (especially network providers), because they have very long and complicated contractual models developed by jurists. It is too slow and too expensive for small companies to deal with such complicated contracts because the large companies are often more concerned with protecting the company behind the contract than with forming good and productive partnerships that all partners benefit from.

"It would be nice if there were some generic guidelines for how to collaborate. However, whether it is realistic, I am more sceptical towards. There are so many different IoT projects with so many different stakeholders. If one were to make templates, there would have to be different kinds of templates."

(Interview: small software developer)

It is clear from the research that it will not be possible to make one standard contractual model, but it is important to work with several models and to build agility into the models. The collaboration models should possibly be worked with as a set of guidelines for how to collaborate in a good and productive way. The guidelines could be accompanied by a set of suggestions for contractual models and formulations that stakeholders could be inspired by and freely combine as needed in each specific project. There is a need for a shared terminology for collaboration and for standardized IoT reference architecture. The work of developing this of course needs to be very much based on national and international standards.

Many of the informants also mentioned 'ethics' as an important issue in relation to partnerships. It is important that all stakeholders work based on the same premises and the same code of conduct. At one of the stakeholder workshops the participants came up with the idea of formulating a 'new Nordic way of doing IoT,' providing shared guiding principles for doing IoT projects, which both ensures the responsibility and benefits of all partners and ensures that customers get secure, reliable, and good solutions.

The municipality representative also mentioned collaboration contracts as important tools for tender bids. Municipalities generally need guidance and help to easier formulate good requirement specifications for IoT-related tender bids, ensuring that all critical issues are included and to ensure good collaboration.

A major issue in partnership collaborations is trust. How can you trust new partners and products? Trust was mentioned in many different ways in the interviews and stakeholder workshops. Especially when it comes to infrastructure projects, where IoT components are buried under ground or mounted in hard-to-reach places, it is important to be sure about the quality and reliability of the components – for example what to do when the developer promises 'up to 16 years battery lifetime warranty' but no minimum?

In IoT, there is often a discrepancy between the heavy and long-lasting infrastructures with which the IT should function and the vulnerability and quickly developing IT parts. Several utility companies flagged the issue of not being able to trust the quality of the hardware as one of the major barriers for getting started with IoT. An integrator with big experience in such projects mentioned that they always enter into partnerships rather than using subsuppliers of sensors for such projects. When the supplier of sensors has the responsibility for replacing them if they do not work or wear out too early, you are more likely to get sensors that

last. Furthermore, there is a problem around the relation between software and hardware, because software development is going very fast and there is constantly new protocols and new security standards emerging, which tends to make the hardware prematurely obsolescent because it is not able to run the new software.

Also, in terms of software, trust is an issue. How do you know whether your partner has control over privacy and cyber security? How do they deal with packet transmission frequency and data availability? How to ensure that the whole backend is able to support increasing amounts of data over time? There is a clear need for guidelines for how to ensure such critical issues, for instance how to replace some of the network or back-end layers.

Not surprisingly, the most essential way to build trust between actors is through previous collaboration and to prove the solutions in the field. To have cases that demonstrate value creation. If the partners have not yet collaborated and if prior testing is not possible, the research indicated that a trust label test could be the best compromise. The informants are both positive and skeptical towards a trust label. There is a clear need for the insurance that a trust label could give, and it could save stakeholders – both suppliers and customers – a lot of time and money. However, the informants pointed out that it should not be some kind of product certification. This would be too laborious, and the market and products are changing too rapidly. Instead, a label could be good as a way of evaluating new companies. 'Is this a serious company who has thought about and designed security, quality, transparency, etc.'?

The municipality representative found such a trust label a very valuable service for municipalities, to whom quality and security are very critical. However, she doubted municipalities would pay for such a service and suggested that companies themselves pay for the blueprint. A small software developer suggested that it would be good with a 2-step label with an initial process for start-ups who want to enter the market and need to prove their reliability, and a second step for companies who have use-cases that can be trust label-tested.

Though the research shows that there is a need for some kind of a trust label, it is less clear how it should be formed and what it should label, just as the business model behind it is not obvious. One of the informants, who works with IoT policy, stated that such a trust label should make sure to build on international and European standards and initiatives (see more in section 4.8).

"There are so many new security and quality standards on their way internationally, and a 'Nordic trust label' should build on this work rather than developing their own ways."

(Interview: IoT research expert)

What is needed is to translate the international policy work into a Nordic context and to simplify it in ways that make it easier to work with in a productive way.

This will give developers and customers a faster and cheaper way to limit risk and ensure trust and quality, rather than to pay for certificates.

NEEDS

- A Nordic code of conduct for how to do good IoT projects
- Inspiration and templates for how to make good, solid, and manageable collaboration models/contracts
- Trust label to ensure quality and reliability of IoT suppliers
- Guidance on standards and certificates

4.6 BUSINESS MODELS

Quite a few informants emphasized as a major challenge the lack of proven business cases and business models that work across the value chain. There is a need for business models that ensure that each part in the value chain receives a fair share of the generated profit, proportionally to its investment, role, importance and/or value addition to the final service or product.

Due to the fragmented market with no established structures, value chains and proven business models for collaboration, and the “problem of plenty”, many IoT development companies exhaust their organization and resources in the attempt to develop and manage the whole package; they work parallel in silos instead of focusing their resources on further strengthening their most competitive positions. This leads to great risk-taking and investments in both sensor/hardware development, programming and software design, sale, distribution to end customers etc. that could beneficially be done by others.

As many IoT projects and start-ups are based on technical ideas and skills, there is often an insufficient focus on developing a solid business case and knowledge of what it takes to make a sustainable business.

“A part of the problem is that the technical solutions are made by engineers with no correspondence to a business case. We need to start with the business case.”
(Interview: Large Software developer)

Strengthening the business focus and ensuring a sustainable model for revenue share in partnerships and ecosystems is not the only challenge.

Customers should be met by a simple price structure that allows them to make a quick ROI estimation. Complex revenue sharing models should be translated into simple price models.

"We don't have any new and exciting business models, but we really see a need for it and would like to be inspired. The problem is that our main partner doesn't really allow us to challenge the 'old' way of doing business together."

(Interview: hardware reseller and consultancy)

We need to develop coherent business models and price models that both ensure a fair revenue sharing among partners in the value chain – and deliver an "as simple as can be" price structure for customers.

NEEDS

- Business cases for inspiration
- Business models and revenue share models for the whole value chain
- Examples of simple price models built on top of revenue sharing models in ecosystems and value chains

4.7 INTEROPERABILITY

Out of the nine challenges mentioned by the informants, only this one was related to technical issues. As mentioned in the introduction, there is a competition going on between different IoT protocols such as SigFox, LoRaWAN and NB IoT on the one hand and different data analytics platforms on the other hand, just as there is a 'war' going on between open systems and proprietary/closed systems. This is a challenge for the market as a whole and especially for customers because it leads to the implementation of different systems that cannot speak with one another. Customers need to decide on a specific protocol/standard and then stick to components and technologies compatible with this system, or they will end up with many different systems that do not cooperate.

"It is a huge problem that the different technical departments in our municipality have bought different systems that do not speak together, so now employees have to log into many different systems to get data, and it is very difficult to process data from the different systems together."

(Interview: representative from a municipality)

Another related issue is that many product developers want to sell their products with their own subscription plans since this provides new income potential

– often described as servitization[18]. However, this results in customers having to have many different products with different subscription plans, and again the many services cannot be integrated with one another. Either customers are locked-in to one central business who can deliver all the needed technology in one system, or they are stuck with many different systems not collaborating.

"Without enforcement of standards, the value and commercial viability of IoT will have difficulty to reach its full potential."[19]

The lack of interoperability generates a risk of creating an ecosystem which is fragmented and developed in silos. Whereas proprietary systems may be good for the individual supplier, it is problematic for the IoT ecosystem as a whole. It is problematic because it makes the market confusing and difficult to navigate in for customers, which may slow down the adoption of IoT. It is also harmful to innovation in IoT development because, as several informants point out, developers involved in the different protocols and platforms are less willing to share knowledge and innovation with one another.

"We sense that there is a resistance in collaborating because we principally represent a proprietary solution. This can of course be solved through edge solutions and most implementations end up as semi-proprietary anyway even though they are based on standard technologies."

(Interview: software and hardware developer)

The Nordic IoT Centre supports all different protocols, systems and platforms. Rather than seeing it as a problem of proprietary systems, we see it as a challenge of lack of interoperability between the different systems. There is a need for developing easier ways to integrate the different systems into one another[20]. It needs to be easy for customers to create interoperability between their services and products. And it needs to be made easier for integrators to combine different standards in one solution. There is a need for creating a generalized framework for IoT with heterogeneous devices and technology support interoperability across products, applications, and services that preclude vendor lock-in.

Furthermore, better interoperability between parts and layers of an IoT system will make it easier to replace parts of the system, if for example one partner goes out of business or one piece of hardware or software becomes obsolete. This

[18] *Download a free publication about servitization published by the Alexandra Institute (in Danish only): https://alexandra.dk/dk/ydelser/servicetransformation*

[19] *Pal et al. (2017): IoT Standardization: The Road Ahead. Page 72.*

[20] *For a project working on making Minimal Interoperability Mechanisms (MIMs) for cities, please see Synchronicity https://synchronicity-iot.eu/*

will not only mean that systems will be longer lasting, it will also create better security for clients investing in expensive systems. Last but not least, it will add to the green agenda by avoiding premature obsolescence and electronic waste.

NEEDS

- Independent guidance for clients who need to choose between different protocols and platforms
- Greater openness for innovation across proprietary systems
- A common framework for interoperability between different systems and technologies

4.8 STANDARDS AND POLICY

With reference to the previous issue, there is a need for a knowledge entity that can help Danish companies, stakeholders and customers to keep up to date with the newest knowledge about policy work, legislation and standards – both nationally and internationally. IoT is a new subject, and in many ways policy, legislation and standards are lagging behind the technical development. However, these things will come to have enormous effects on how companies can and should develop their products. It is therefore very valuable for especially SMEs, who do not have the resources to keep up to date themselves, to have easy access to current knowledge and development.

"There is so much going on within standardization in the EU and around the world. If you want to support the IoT ecosystem, you need to keep yourself up to date with these initiatives and help translate it to the companies for whom this kind of knowledge can be very difficult to understand."
(Interview: IoT research expert)

It is important to provide elaborate policy guidance to avoid a fragmented development of IoT ecosystems. Standards are being developed in many different international bodies and alliances such as ITU, IEEE, oneM2M, 3GPP, and the many different Standard Development Organizations (SDOs) across the world. Especially, there is great focus on standardization work within security and privacy, interoperability, reliability, agility and scalability.[21] It will be crucial for

[21] *For an introduction to standardization work on IoT, see the article IoT Standardization: The Road Ahead' by Pal et al. 2017 https://www.intechopen.com/books/internet-of-things-technology-applications-and-standardization/iot-standardization-the-road-ahead*

export possibilities that Nordic companies are well informed about and thus able to comply with the European and international technical standards. Furthermore, there is a need for an independent organization which can gather the many different IoT stakeholders and initiate policy work that can ensure good and stabile conditions for IoT development in the Nordic region.

NEEDS

- Information about new standards, policies and regulation
- A body to handle policy work and ensuring stable and profitable conditions for IoT

4.9 KNOWLEDGE SHARING

There is a need for sharing knowledge in order to elevate and improve IoT development in the Nordic region. It is a general challenge in all business areas that companies want to hold on to their own knowledge and IPRs to stay competitive, which is of course necessary. However, most of the informants also acknowledged that failure to share knowledge is bad for everybody and can be a barrier to development. So there is a need for knowledge sharing in ways that do not compromise or challenge IPRs.

One of the issues mentioned was that a lot of time and money is wasted because many different actors test the same technologies and set-ups independently instead of learning from each other's tests, experience, and knowledge. It was also mentioned that there is a need for making testing easier, faster, and cheaper. Another suggestion was to become better at sharing knowledge in verticals. Technological solutions from one sector can be transferred to and create value in other sectors. This will widen the scope and business potentials of IoT while saving development costs. This is a less risky way to collaborate.

At the stakeholder workshops, the participants flagged the importance of having safe spaces for sharing knowledge – especially knowledge concerning issues that are difficult and troublesome. Even a space for sharing mistakes as there is a lot to learn from one another's mistakes.

"It has been very valuable to share ideas and problems here today. I found that you created a space where everyone has been more open than normally, and I have gotten much more out of it than many of the more generic IoT information events."
(Stakeholder workshop in Copenhagen)

Many of the informants also mentioned PPPs (public-private partnerships),Triple Helix projects (public institutions, universities and private companies) and Quadruple Helix (including the general public) – as generative spaces for developing IoT. Since this way of developing IoT is already quite widespread in Denmark, there did not seem to be any particular need or issues to address here, besides the importance of also thinking about how the needs and challenges of private companies can productively be transported into the universities and thus shape future research.

The last important issue addressed was the relevance of coordinating knowledge and the market across east and west Denmark, which still seems to be a challenge. And to include a wider selection of countries in the Nordic region such as Ireland, Finland, Sweden, Norway, Northern Germany etc. in the knowledge and business sharing and collaboration. Furthermore, there is a need for a strong knowledge player who can keep up to date with and inform about new knowledge from universities and other countries.

NEEDS

- Gathering and communicating knowledge
- Safe spaces for sharing information about all the difficult issues
- Disseminating knowledge and challenges from private businesses to university and research institutions
- Collaboration and knowledge sharing across Denmark and among countries in the Nordic region

5 WHERE TO GO NEXT

In this whitepaper we have analyzed the knowledge gathered through 2 stakeholder workshops and 11 interviews with relevant actors within the IoT development. This work has resulted in a description of nine challenges and related needs for services and tools which can help strengthen the Nordic IoT ecosystem:

	CHALLENGES AND NEEDS
1	**CHALLENGE**: MAKE IT REAL Needs: to educate the public and clients and engagement of industry associations
2	**CHALLENGE:** PROBLEM OF PLENTY Needs: actor mapping and independent and technology agnostic advisors
3	**CHALLENGES:** FROM TECHNOLOGY-DRIVEN TO USER NEEDS-DRIVEN APPROACHES TO IOT Needs: analyzing and visualizing actual user needs and value creation
4	**CHALLENGE:** MATCHMAKING **Needs**: a need for a marketplace for matching demand and supply
5	**CHALLENGE:** COLLABORATION, PARTNERSHIPS AND TRUST **Needs**: a 'new Nordic code of conduct,' providing shared guiding principles
6	**CHALLENGE:** BUSINESS MODELS Needs: business cases and new business models and revenue-share models for the whole value chain
7	**CHALLENGE:** INTEROPERABILITY Needs: generalized framework for the IoT interoperability
8	**CHALLENGE:** STANDARDS AND POLICY Needs: an independent actor providing knowledge on policy and standardization
9	**CHALLENGE:** KNOWLEDGE SHARING Needs: sharing of knowledge and experiences across the Nordic region

If we compare the findings in this whitepaper with other research in the IoT field, as presented in section 3), we thus see a slightly different focus emerging.

Whereas many other reports focus very much on the need for technological development, we see in this present research a clear call for a greater focus on the business and the social issues around developing IoT. There is a smaller need to focus on technological development, as this seems to be something that the IoT developers already feel capable of. The technological market is ready but we need use-cases and business cases as well as dissemination of knowledge. The results presented in this whitepaper derive from the first year of a two-year research project. The remaining year will be used to develop specific tools and services which can help accommodate the challenges and needs and to further explore and build up the IoT ecosystem in the Nordic region.

The concept of an ecosystem is not only the title of this research project. It is also widely used in IoT, and it did seem like a concept that our informants found it natural to work with. However, through our research we have also experienced that the definition of an IoT ecosystem can mean and include/exclude very different things for the different stakeholders. What does an IoT ecosystem look like and how are the actors in the ecosystem interconnected and interdependent of one another? What is needed for all the actors in an ecosystem to thrive and to benefit from one another? And not least, how can ecosystems be structured, organized and orchestrated in order to provide the most nourishing ground for strengthening IoT development and implementation?

In the remaining part of our research project, the Nordic IoT Centre will work on and present a clearer definition of the IoT ecosystem and how to approach the work. The purpose of such a definition is not to set in stone how one is to define and understand an IoT ecosystem – what the IoT ecosystem is and what it entails depends entirely from where in the ecosystem one is positioned and which core competences one is working with! However, the purpose of making a Nordic IoT Centre definition is to help our partners and other interested developers to specify and explain their own role in the ecosystem, just as it will make it easier for clients, new to IoT, to understand and get started with new IoT projects. Last but not least, the coming definition will support the Nordic IoT Centre in specifying our own role in the ecosystem as a neutral and technology agnostic advisor and orchestrator of IoT projects, helping clients getting started and supporting the many IoT actors in collaborating and strengthening one another in future IoT projects.

We hope you will follow us in our future work.

6 APPENDIX: INTERVIEW QUESTIONAIRE

Ref.	Question
1	What is the brief description of what your organization does?
2	What is your interest in IoT eco systems?
3	What should be main focus in developing a Danish/Nordic IoT ecosystem?
4	What kind of services and content would make it attractive for your company to support/use an IoT ecosystem platform?
5	What are the main benefits of developing IoT with partners?
6	What are the barriers for developing IoT with partners
7	What type of partners would be useful for you to find in an IoT ecosystem?
8	Do you have a need for collaboration models for developing IoT with partners?
9	Would you like to contribute or develop new/better collaboration models for the IoT ecosystem (based on your experience)?
10	What competences does your current IoT development rely on?
11	Do you have contractual models between you and your partners? Are you willing to share them (as inspiration in our development of an IoT-platform)

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