
# EIT ICT Labs Innovation Radar

## 2013 Annual Trend Report

Insights into promising ICT-related developments and trends

December 2013

Innovation Radar

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# CONTENT

# FOREWORD

Since its inception, the Innovation Radar has been adorned with the quantitative goal of presenting trends in ICT, as part of its foresighting efforts. This has been important for reaching towards the overarching goal of thought leadership on ICT in Europe. Already in 2011, T-Labs was part of the radar team and that year contributed more than 100 important trends, resulting from their international scouting network. These trends were then used by, and amalgamated with, the trend observations made by other EIT ICT Labs experts and by the radar team.

In 2012, there were more than 200 trends reported on by T-Labs, and that year saw the publication of the first proper annual trend report. I was happy to see it being used in the planning and execution of several foresighting event this year. The report was made public via the Web (Publications page) in the spring of 2013, and still gets downloaded every week.

Now, the output has again grown, but not only measured by the number of trends detailed. This year saw the EIT ICT Labs Innovation Areas driving various foresighting activities, and the methodology of the Innovation Radar has been adapted to this fact. The trends reported herein are now clearly linked to the Innovation Areas, facilitating uptake, and making possible completely new forms of ties to the rest of the results coming out of EIT ICT Labs Innovation Intelligence. The breadth of the scouting and the depth of the underlying analysis vouches for relevant and quality-assured material.

Access to the tools and methods of T-Labs has been beneficial to the workings of EIT ICT Labs throughout 2013, and it has also been used in the strategic planning. It is my firm belief that this year's annual trend report will be widely studied, first inside and later outside, the innovation community that is EIT ICT Labs. I am sure all professionals will find new results or products on these pages, and with thanks to the T-Labs team for excellent cooperation throughout the year, I wish you all a good read!

**Magnus Boman**
(Lead, Innovation Radar)





# EXECUTIVE SUMMARY
## EXCITING DEVELOPMENTS IN 2013

This report provides an overview of top ICT trends and how these trends will touch EIT ICT Labs' Action Lines (AL) in the future. Here is a brief summary of the trends:


- **Enterprise Mobile Security** Single unified computing devices for business and personal use are improving the mobile enterprise security space.
- **Optical Supercomputing** Faster computers and networks use photonics to provide the opportunity to analyse complex data in less time.
- **Collaborative Consumption** Technology takes sharing to a massive scale.
- **Virtual Currency** Virtual crypto-currencies emerge, posing technical, regulatory, societal and economic challenges, especially for financial institutions and governments.
- **Context-based Interfaces, Ambient Computing** Users will accomplish tasks that would normally require a multitude of different actions using interfaces based on contexts.
- **Deep Learning** Technologies are enabling computers to serve many tasks that only humans are able to do today.
- **Wearable Tech** Clothes and accessories become key parts of our connected life. Spaces are becoming sensitive and responsive to individuals.
- **Rural Connection** Rural sectors are being modernised to become more competitive in the global economy.

# METHODOLOGY

## Scouting

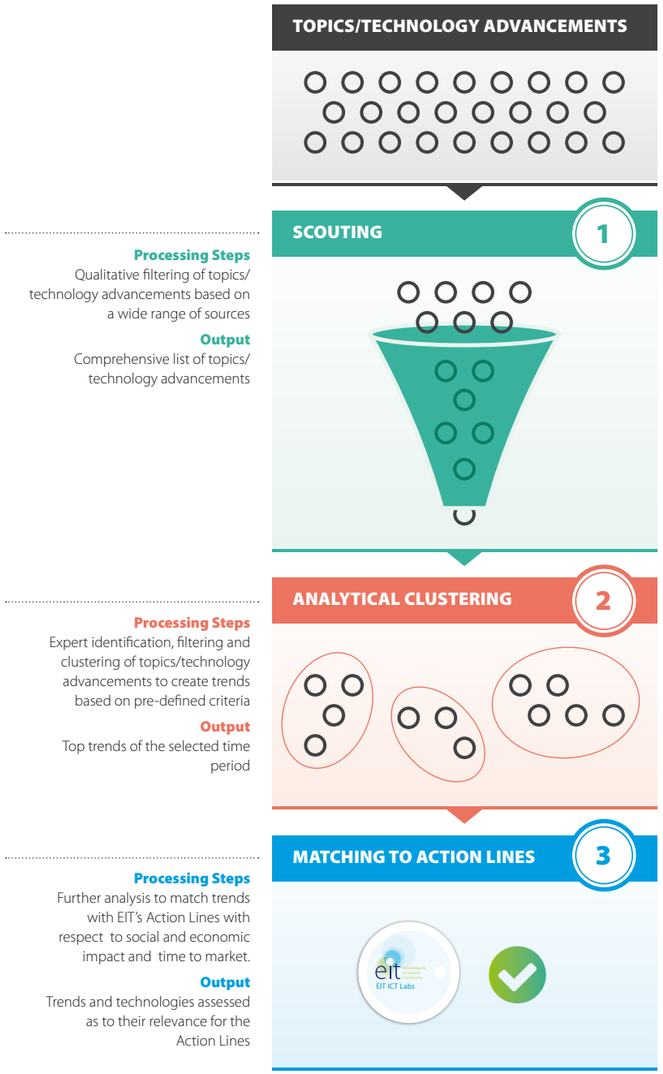
Scouting has been the method of choice in order to identify relevant developments and trends in ICT. Scouts have been facilitated for primary and secondary market research at conferences, through dedicated databases, other online and offline sources, as well as the observation of R&D activities in industry and academia, and venture capital and incubator activities. Search fields have been defined by EIT CT Labs' Innovation Areas and beyond. All data has been collected in a dedicated scouting database (PEACOQ) and augmented by categorisation, tagging, and other metadata. The result has been a comprehensive list of (after filtering of mismatches and double entries) 127 so called topics – descriptions of (mostly) technological advancements.

## Analytical Clustering

In a second step, the identified topics have been analysed and clustered. With the help of experts from EIT ICT Labs partner organisations trends have been derived from the long-list of topics. A minimum of four such topics were required to define a significant trend. These had to constitute a clear proposition as a technological enabler. The clustering resulted in 9 selected trends presented in this report.

## Matching to Action Lines

After defining and describing trends, these trends were matched with EIT ICT Lab's Action Lines, in order to identify relevant use cases, possible synergies coming from existing competencies, as well as to enable deriving recommendations for action. Implications for each affected Action Line have been described, example use cases developed, and examples from the market given.






# 2013 TRENDS DETAILS
TOP TECHNOLOGICAL AREAS TO OBSERVE

# TRENDS MATCHED TO ACTION LINES

## Future Cloud

This topic gathers the best researchers in Europe to focus on system research with concrete demonstrators in useable tools, open source, or cloud components. Results will be exposed systematically to entrepreneurs and VCs to create new business opportunities.

- Big Data
- Artificial Intelligence

- Distr. Computing

- Integrated NAC
- Mobile Virtualization

## Cyber-Physical Systems

Cyber-physical systems (CPS) enable the physical world to merge with the virtual, leading to an Internet of things, data and services. One example of CPS is an intelligent manufacturing line, where the machine can perform many work processes by communicating with the components.

- Connected Home and Internet of Things

- Embedded Wireless Nets & User-Machine Interface

- Semantics and Self-programming

## Future Urban Life & Mobility

Statistics, forecasts and population studies confirm the continuous migration of population towards cities. It follows the goal of becoming absolutely safe (zero accident) and sustainable (zero emission). Prepares the ground for innovators by applying instruments on research results supporting business across Europe.

- Autonomous Cars

- Car sharing, Home sharing, Virtual Workforce

- Drone Networks

- Brain-Controlled Interfaces

## Health and Well-being

With an ageing population and growing consumer empowerment, the call for a user-centric approach towards Health and Well-being is imperative. Supporting people with ICT-based solutions can improve the quality of life.

- Sensor And Microelectronics

- Automated Tele-diagnostics

- Behavioral Analytics

## Future Networking Solutions

With converged integrated infrastructure, merging voice and data transmissions, the development of new communication technologies and networking architectures, can be fostered. This topic features the emergence of new services carried over these networks.

This topic also addresses the challenges of providing an ICT structure supporting producers and consumers exchanging rich digitized media across heterogeneous domains. This entails all layers, from the network infrastructure to the user application layer.

- All-Opt Nets
- Quantum Nets

- Low-Cost Computing
- P2P Networks

- Interactive Entertainment

- Enterprise App Stores

- Virtual Workforces





## Privacy, Security & Trust

Understanding how information technologies impact the privacy of individuals and developing new privacy-preserving and secure technologies to protect them. This Action Line is transversal to most of the action lines of EIT ICT Labs.

- Microkernel
- Mobile Architecture

- Encryption
- Digital Economy
- Open Transactions

## Smart Energy Systems

European ICT innovations drive future energy systems. Meeting EU's climate change and energy policy objectives for 2020 and beyond will require a major transformation of our electricity infrastructure.

- Self-Programming
- Task Automation

- Power Source Optimization

- Crowdfunding

## Smart Spaces

Smart Spaces refer to built environments that are enabled for co-operation of smart objects and systems, and for ubiquitous interaction with frequent and sporadic visitors. Prime business scenarios include smart retail environments and public areas providing better service to customers.

- Context Aware Technologies
- Internet of Things

- Auth. & Ident.
- Shape-Shifters
- Interactive Entertainment

### SIGNS AND SYMBOLS USED IN THE FOLLOWING:

Ambient Computing

Enterprise Mobile Security

Context-based Interfaces

Virtual Currency

Optical Super-Computing

Collaborative Consumption

Rural Connection

Wearable Tech

Deep Learning

Relevance


Time-to-market

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

Estimated time to market highlighted.

- indicates a related Trend. Other trends may apply.

# Ambient Computing
## The world as a massive sensor for our needs.

Thanks to advances in technology, spaces are becoming sensitive and responsive to individuals. Connected devices that are already existent are starting to work together to support users in their everyday activities. As electronics become smaller and smarter, computing capabilities will become invisible and more integrated into our environment, leaving only perceivable interfaces. Development in research has shown a clear direction towards creating electronic environments which will be able to become aware of the user context, adapt and anticipate needs, and personalise the user experience based on these factors.

Early progress has been seen in the field of connected cities, electrifying street signs or sidewalks and making them interacting with pedestrians. Developments in the arena of connected home feature household devices linked to the internet, enabling people to monitor and control them remotely. Other recently developed solutions empower context aware applications that include location-based selection, interest sensing and image recognition to simplify life and work.

### Related Trends

- Connected Home
- Autonomous Vehicles
- Internet of Things
- Context Aware Technologies

### Affected Action Lines

- Cyber-Physical Systems
- Future Urban Life and Mobility
- Smart Spaces

## Human-Centered Computing Enhances Quality Of Life

### Impact of Ambient Computing

Technology is shifting towards human-centered computing, boosting user experience to a new level, where seamless connectivity along with unobtrusive devices will be predominant.


**SOCIAL IMPACT:** Overall quality of life of society will be enhanced by further customisation of their lifestyles, time savings, easier communication and the convenience of automatic and universal on-time information delivery. Ambient Computing will add to peoples' safety, e.g. in transport and health. However, loss of privacy brings up concerns as soon as any third party gets control over information.


**ECONOMIC IMPACT:** Demand of sensors that support Ambient Computing will soar. By 2016, the global sensors market will have $250bn in revenue, growing at a 9% CAGR.[1] Also, additional cost savings will be generated across many industries such as real estate, retail, advertising and insurance as sensors will provide granular insights in real-time allowing businesses to act on them like never before.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

[1] InTechno (2013), [2] Network Advertising Initiative (2009)





## Affected Action Lines

### Cyber-Physical Systems


Multiple connected devices in the home will be monitored and controlled by a centralised, connected platform. This system will have the intelligence to react according to dynamic rules based on the user's behaviours, preferences and needs.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Smart Spaces


Public venues and buildings will become more digitised and equipped with sensor networks. When visiting these places, this would enable citizens and visitors to have a personalised experience like automatic navigation based on interest-based itinerary.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Future Urban Life & Mobility


Technology develops towards autonomous vehicles that are interconnected. The massive computations based on the data from various sensors inside and outside the vehicles will make mobility less prone to human failure. Hence, security in traffic can be improved and traffic flow optimised.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

## Connected Home: Use Case for Cyber-Physical Systems

### Description


Advancements in Wireless Sensor Networks will provide the dynamic and flexible, yet standardised structure for the transmission of data that are acquired from the home environment by sensors. The same network will connect with devices' actuators, enabling them to perform physical changes in the environment. Hence, distinct devices will be interconnected, making their data globally available.

Home devices and objects can thus be monitored and controlled by a centralised, connected platform that can still be customised according to the user's preferences. Going even further, embedding such systems into each and every object around people would enable these objects to monitor and control their own sensors and actuators, and to collect data from the physical surroundings, independent of the user. For example, the coffee machine could be interconnected with the clock and automatically start making coffee according to the user's preferences ten minutes before the alarm. This would lead to a network of home devices which supports residents fully automatically, but can still be customised and controlled remotely.

### Connected Home Solutions

SmartThings' solution consists of wireless sensors that relay information to a dedicated in-house hub, which in turn connects to a cloud-based platform. Users can monitor and control these various smart devices through a smartphone app.

### Multi-Touch Smart Floor

IBM recently patented a multi-touch floor embedded with sensors that identify shapes, weights, and locations of objects in contact with it. The technology can retrieve user information and perform actions based on this information, e.g. triggering an alarm.


# Collaborative Consumption
## Mine, yours, or ours?

Collaborative Consumption (also called collaborative economy or sharing economy) refers to economic and social systems that enable shared access to goods, services, data and talent. This model has been widely discussed in the media since the global recession of 2008. But when Avis Budget Group announced it would acquire Zipcar for $500 million in early January, it became clear that the idea is not just a passing fad.

The power of recent technologies, such as mobile platforms, are being important catalysts for this model. In fact, the pervasiveness of mobile technology is making it possible to scale this model in ways that have never been possible before.

Companies like Zipcar and Airbnb have paved the way here, but a host of startups have surfaced recently, too. These startups are creating the technology to make a collaborative consumption possible. While the core technology is not recent, its application and specificity really is.

### Related Trends

- Car Sharing
- Real Estate Sharing
- Virtual Workforces
- Crowdfunding

### Affected Action Lines

- Future Urban Life and Mobility
- Future Networking Solutions
- Smart Energy Systems


## A shift requiring new business models

### Impact of Collaborative Consumption

From an economic perspective, collaborative consumption looks promising. Moreover, the sharing economy creates significant value around a future economy which is environmentally sustainable.


**SOCIAL IMPACT:** Populations will take advantage of platforms that give opportunities to monetise underutilised assets and skills. This will rise the supply of services, decreasing their price and boosting the overall social welfare. Unemployment and underemployment could be reduced. The model also creates many positive environmental impacts, such as reducing the number of privately owned cars in cities.


**ECONOMIC IMPACT:** Rachel Botsman, the author of a book on the subject, says the consumer peer-to-peer rental market alone is worth $26bn today. Based on market research, startup valuations, funding, and revenues multipliers, by 2017, the entire collaborative consumption could be bigger than $72bn. This market will experience strong growth rates (CAGR 52%) due to high demand of sharing cars and real estate.[1]

**Time-to-market** | < 3 Years | **3 – 5 Years** | > 5 Years

[1] Detecon Studies (2012)





## Affected Action Lines

### Future Urban Life & Mobility


Cost of labour has increased constantly since 2006,[1] pushing businesses to seek alternative ways to drive costs down. Using mobile phones and connectivity, companies will have mobile subscribers to perform tasks, such as price comparisons and site surveys. Automated systems will asses their quality Automated systems will assess their quality and compensate based on results.

**Time-to-market** | < 3 Years | **3 – 5 Years** | > 5 Years

[1] OECD (2006)

### Network Solutions for Future Media


Content will not only be distributed in different ways but also it will be created using unprecedented techniques. Crowds will be using tools to become the next producers, providing high-quality media content, such as news and entertainment. Imagine a soap opera produced using crowdsourcing technologies.

**Time-to-market** | **< 3 Years** | 3 – 5 Years | > 5 Years

### Smart Energy Systems


Deploying smart energy solutions across the world requires extensive capital usage. These projects are consistently considered high risks to traditional creditors, creating a credit crunch for these particular initiatives. Utilising crowdfunding platforms, these projects will be financed by their communities.

**Time-to-market** | < 3 Years | **3 – 5 Years** | > 5 Years

## Virtual Workforces: Use Case for ULM

### Description


Welcome to the era of virtual workforces were businesses are able to quickly hire thousands of temporary workers at once, all through the worker's smartphone. Workers can do all the work through their phone and submit it instantly. They will be recruited via their smartphone based on their location and behaviours. For instance, pizza restaurants will be able to hire people to deliver pizzas based on their daily commute.

In this use case, businesses will not only use digital marketing and behavioural analytics to sell products, but also hire any smartphone user, such as housewives and taxi drivers as their temporary workers. These workers will perform tasks, like taking store pictures or checking shelf space in stores on the other side of the world. This solution is also applicable for end consumers which are able to 'outsource' their errands, such as picking up the laundry. Since these activities happen in real-time, tasks are done faster with a fraction of the cost. Advanced analytics algorithms will validate the work, ensuring high quality and reliability. These solutions provide a global shared pool of labour which is inexpensive, location-relevant, on-demand, elastic, and available to anyone.

#### Mobile Workforces

Gigwalk offers companies 325,000 employees (app users) across the US who can check products and places. They offer services like store audits and mystery shoppers which they can do instantly and at a very low cost.

#### Outsource your errands

TaskRabbit is an online and mobile marketplace that helps people and businesses to hire others to outsource their errands and tasks. Food delivery and assembly of IKEA furniture are some examples of offered services.

# Context-based Interfaces
## Interfaces for more intuitive object interaction.

Today's consumer electronics devices typically use interfaces that have limited user interaction capabilities, reducing adoption and usage of these devices in specific situations. People want to provide and retrieve information, control objects and rely on their support in every situation – mostly while doing something else. Hence, redefining the usability of these devices is a key aspect for the future of consumer electronics.

Touch-free interfaces are already on the rise. Recently observed developments have featured interfaces controlled by gestures, eyes, voice and the brain. User interaction will be possible with almost every existing object. Interfaces will be designed depending on the context they will be used in. Cars will provide a very different phone interface than the one in the office. For everything else, shape-shifting mobile devices with various in- and output capabilities are being developed. In the future, these interfaces will evolve to a point were they can sense the context they are used in and automatically adapt to this context.

### Related Trends

- Brain-Controlled Interfaces
- Shape-Shifting Devices
- Interactive Entertainment
- Authentication & Identification

### Affected Action Lines

- Future Urban Life and Mobility
- Future Networking Solutions
- Smart Spaces

## Enabling natural information and command flows

### Impact of Context-based Interfaces

A single user command will accomplish tasks that would normally require a multitude of different actions. Hence, context-based interfaces will boost the natural information and command flow.


**SOCIAL IMPACT:** People will communicate faster, control things more efficiently and intuitively. Especially seniors and people with disabilities will benefit from more appropriate context-based interfaces. They provide more safety in everyday situations, like e.g. navigating or texting while driving, or controlling rescue vehicles remotely. However, if misused, these interfaces might also pose a threat to privacy and health.


**ECONOMIC IMPACT:** In a business environment, context-sensitive interfaces will spur peoples' productivity and efficient collaboration. Choosing the right interfaces for products could be a major differentiator for manufacturers. However, if the industries do not agree on common standards for device control, user friendliness and thus adoption will be hampered.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|





## Affected Action Lines

### Future Networking Solutions


People will create, control and consume smart media in a much more natural and efficient manner. Media experience will improve, making it more interactive. Personal devices that shift their shape according to the context is just one example of what the future will bring.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Smart Spaces


People will be able to interact with any object: street signs, buildings or furniture. These objects will have a specific type of interface to offer the relevant and interactive assistance to its user. Customer services and authentication processes will radically change.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Future Urban Life & Mobility


Advanced interfaces will open up mobility for people with physical disabilities by enhancing navigation and guidance services. They will control vehicles either sitting in it or steering it remotely using the brain, gestures or voice. While steering, they will be able to easily and safely interact e.g. with communication tools at the same time.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

## Interactive Entertainment: Use Case for FNS

### Description


The way that people experience media is still not as natural as one might wish. Special devices have to be used to play games or switch programs on TV. Particularly consuming and interacting with media content will become much more efficient and natural with deployment of advanced interfaces into media objects.

TV users for example will not need to get their remote control to switch programs on the augmented screen in the living room because they can switch by voice commands. To turn on music, they simply need to make a gesture that is recognised by the player which sits in another room. It will also enable spectators to interact in real-time with TV shows from home. Movements, voice, eyes and brain control might also be applied to virtualised objects on the screen for more interactive gaming. Mobile devices will still be used, but they will be able to shift their shapes depending on what the user wants to do. They can turn into a newspaper when the user feels like reading, into a gaming console when they feel like gaming – or simply into a phone when they want to call someone. All that people would have to carry around with them would be only one personal device for a multitude of different use cases.

#### Wi-Fi Gesture Controlling

A Wi-Fi receiver enables motion-control devices without having to stand in front of them. The technology listens to wireless transmission from devices around and uses an algorithm to detect frequency changes in signals caused by movements.

#### Shape-shifting devices

Touch screens can morph into different shapes. Smart Memory Alloys have been sewn into a tiled touch screen and actuated by passing current through them. This makes the tiles move, shifting the shape of the screen.

# Deep Learning
## One step closer to true Artificial Intelligence.

Deep Learning (DL) is essentially a collection of techniques that aim to train computers how to learn by using artificial neural networks. While DL often was considered too slow for practical use, recent advancements in hardware, mathematical algorithms, and probabilistic models have driven a resurgence of this field.

This year, important breakthroughs in speech recognition, object and image recognition, natural language processing and other areas have been seen.

Such advancements are possible indicators that computers are getting smarter, showing promising steps towards a true Artificial Intelligence.

As more powerful and more affordable machines reach the market, we expect to see more focus on this topic from R&D centres and entrepreneurs, spawning a new wave of innovation in this space.

### Related Trends

- Behavioural Analytics Platforms
- Self-Programming Software
- Search and Semantic Web
- Task Automation

### Affected Action Lines

- Cyber-Physical Systems
- Health and Well-being
- Smart Energy Systems

## Computers will learn beyond the knowledge of humans

### Impact of Deep Learning

In essence, Deep Learning will enable computers to undertake and automate many tasks that only humans are able to do today.


**SOCIAL IMPACT:** DL will have structural impacts in society by enabling computers to automate many highly skilled jobs, such as drivers, interpreters, factory workers and business analysts. However, professionals predict that DL will not be widely adopted for another 20 years.[1]


**ECONOMIC IMPACT:** DL algorithms are being considered for an array of high impact applications with promising financial returns, such as drug discovery and financial analytics. While this is in very early stages, investors have still shown a clear interest in the topic, since startups focusing on DL, such as Vicarious, have raised millions of dollars in venture funding over the last months.[2]

**Time-to-market** | < 3 Years | 3 – 5 Years | **> 5 Years**

[1] IT Technology Review (2012), [2] Crunchbase (2013)





## Affected Action Lines

### Health and Well-Being


Deep Learning (DL) systems are very helpful in cases where there is relatively scarce data, as it is the case with drug discovery. DL systems could streamline the process of discovering drugs by reading datasets, describing the chemical structure of thousands of different molecules and determining which molecule is most likely to be an effective drug agent.

**Time-to-market** | < 3 Years | 3 – 5 Years | **> 5 Years**

### Cyber-Physical Systems


The factories of the future will be intelligent. DL software embedded across production lines will enable machines to automatically analyse the data that they generate, learn from it and drive actions according to predictive models. For instance, factories will turn on or off machines in production lines based on auto-generated revenue forecasts.

**Time-to-market** | < 3 Years | 3 – 5 Years | **> 5 Years**

### Smart Energy Systems


DL technology could also optimise building management systems. The solution could make predictions and for example set temperatures in real time based on weather information and historic usage. The idea would be to manage entire buildings without human interaction.

**Time-to-market** | **< 3 Years** | 3 – 5 Years | > 5 Years

## Predictive and Behavioral Analytics: Use Case for HWB

### Description


In the last months, important developments of DL systems have touched the health space. There have been significant advances in drug discovery and patient management systems. DL systems have been used to streamline the process of discovering drugs, where costs of R&D can be as high as $1.9 bn.[1] Currently, to find new drugs, pharmaceutical companies need to identify how living organisms react to millions of compounds, making this process time- and effort-intensive. If DL systems are fed with enough data over time, they will be able to learn complex combinations and make unprecedented linkages. This will make faster drug discoveries possible, using altogether less resources. Recent DL applications are now able to analyse passive data (smartphone sensors) and active data (patient-reported outcomes) from mobile phones as a way to understand the linkage between population behaviours and disease outbreaks. Currently, this technology can identify high-risk patients and alert for patient interventions based on their context. In the future, this platform will be able to predict and alert disease outbreaks before they happen. Also, with this software, hospitals could proactively order supplies before outbreaks happen and governments could uncover valuable insights that could directly influence health policies.

#### Behavioural Analytics Platform

Ginger.io uses sensor data and machine learning to track, passively and actively, patients' health. By analysing data the software is able to understand the link between patient behaviour and disease outbreaks.

#### Software for drug discovery

For the first time in history, a DL software won a competition to identify new drugs. From a dataset describing the chemical structure of thousands of molecules, the software determined which molecule was most likely to be an effective drug agent.

[1] Combichemistry.com (2013)

# Enterprise Mobile Security
## Taking control of BYOD.

Use of consumer devices in the enterprise environment creates a significant security threat for businesses. Solutions like 'Bring Your Own Device' (BYOD) are expected to grow significantly at a CAGR of 27% between 2013 and 2016.[1] Such devices are expected to store sensitive data owned by several parties, becoming an easy target for fraudsters. They are also expected to run third-party applications, e.g. apps for private use whose origin, quality and functionality is not directly or even indirectly controlled by the employer. Retaining control is now a vital focus for the enterprise.

Finding security solutions in the mobile enterprise environment is now more critical than ever before. Emerging solutions include microkernel security, developments that add more security to cloud services, or the integration of various distinct tools into one comprehensive network-access control solution.

### Related Trends

- Integrated NAC
- Enterprise App Stores
- Secure Microkernel Architecture
- On-demand mobile Virtualisation

### Affected Action Lines

- Future Cloud
- Future Networking Solutions
- Privacy, Security & Trust

## Rising threats and emerging security solutions

### Impact of Enterprise Mobile Security

A secure mobile enterprise would be one step further to having a single unified computing device for business and personal use.


**SOCIAL IMPACT:** Employees will be able to use only one mobile device for private and business purposes instead of constantly having to switch between two devices with different functionality. They will be able to combine work and personal lives. This increases their productivity, flexibility and overall satisfaction, and it decreases their readiness to use confidential business data in a private context.[1,2]


**ECONOMIC IMPACT:** Economic Impact: Security is one of the top concerns that prevent CIOs from adopting BYOD.[3] Companies would save opportunity, productivity and person-hour costs of damaged devices if they had more control over devices in the network.[4] A company's productivity gains from comprehensive BYOD could result in savings of 37 min a week and up to $1,650 annually per mobile user.[1]

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

[1] Cisco IBSG (2013) /NICTA (2011), [2] IBM (2013), [3] Gartner (2012), [4] TRENDMICRO (2012)





## Affected Action Lines

### Future Cloud


More and more services that are retrieved from mobile devices make use of cloud computing. Accordingly, access to these services should be better secured. Thus, future developments will focus on improving the security of databases, better data encryption, and securing interfaces and APIs.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Privacy, Security and Trust


Applying security measures on mobile devices should be started at the base: the kernel. An autonomous, small and secure microkernel is a promising solution to separate trusted and non-trusted software, and restrict access to confidential information and critical resources.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Future Networking Solutions


BYOD solutions will be implemented free of traditional user endpoint security concerns. Future technologies shift policy control from single devices of applications to an entire workflow of apps executed on different devices. This way, user experience can be preserved while at the same time confidential data is kept secure.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

## Mobile Virtualisation: Use Case for FNS

### Description


Many companies which accepted BYOD turned to mobile device management (MDM) technology to help them enforce corporate policies on users' mobile devices. As the numbers of employee-owned devices to be taken care of and security threats multiply with the broader acceptance of BYOD, IT professionals consider MDM an inconvenient approach.[1]

This benefits the rise of seamless, on-demand mobile virtualisation. Containers, app wrapping and mobile device virtualisation (mobile VDI) will be considered better alternatives to segregate personal and corporate data on personally owned devices. It takes the administrative burden of managing mobile devices out of the hands of administrators. They can implement a BYOD solution free of many traditional endpoint concerns. Future technologies can even shift policy control from single devices to an entire workflow of apps executed on different devices. So, an app on one device that is invoked by a corporate app on another device could be treated with the same policy. Capabilities like this will preserve user experience and further increase mobilisation of enterprise resources, while at the same time keeping confidential data secure.

### HTML5 Representation of Confidential Data

Armor5 connects mobile phones to intranet data through VPN and its own servers. There, an HTML5 representation of the data is created and sent to the device. When the browser is closed, there is no trace of the data on the device.

### Detached Workspace on Smartphones

This App creates a detached workspace that restricts pre-selected applications from accessing different sets of data depending on the context they are used in (work or private). Users log on and can access corporate data with those apps over a VPN.

[1] cio.com (2013)

## Secure Microkernel Arch.: Use Case for PST

### Description


The trustworthiness of a software system is much about its size. Thus, a bigger system, however well-coded, has inherently more bugs than a small system.[1]

Additionally, software systems are largely susceptible to malicious software due to the inability of the underlying base system to enforce the principle of least authority, which undermines the provision of security by higher-level layers.[1] As the kernel controls the hardware at the lowest level, any kernel bug is potentially fatal for a system, and securing a device should be started at the kernel.

By combining those principles, an autonomous, small and secure microkernel can be a promising security solution. Several domains could be coexisting e.g. on a smartphone. Trusted software can run adjacent with untrusted software, having separate access to different resources

#### Secure Microkernel

To bypass the security risk of a monolithic kernel in a Smartphone, a technique to load a secured micro-kernel as software prior to booting the OS has been developed. After loading, it allocates resources to the OS and apps via protected virtualisation.

#### Detached Workspace on Smartphones

SeL4, a microkernel has been released, which provides a minimal and efficient lowest software level, and is the only part of the software that is executed in the privileged mode of the hardware. That way, it allows software stacks to be isolated.

[1] NICTA (2011)




**OVERVIEW OF 2013 TRENDS**

# Optical Supercomputing
## Limits of current tech drives optics innovations.

Supercomputers allow scientists and engineers to solve computational problems of enormous size and complexity. In the pursuit of increasing the processing power and decreasing the size of these computational units, silicon devices conducting electricity are reaching their physical limits. In order to make future computing demands feasible, optics present a promising solution. Since light beams do not interfere with each other, they can transmit signals through places where electromagnetic interference would block transmission. Hence, devices for optical computers are less costly to built and operate, and they can be smaller and faster which is particularly important to meet the demands of high performance communication in data centres and backbones.

Today, leading corporations and universities are increasingly focusing on photonics. Integrating optical devices onto silicon chips, controlling light within tiny spaces and transmitting optical signals securely exemplify this disruption.

### Related Trends

- All-optical Networks
- Distr. Quantum Networks
- Big Data
- Artificial Intelligence

### Affected Action Lines

- Future Cloud
- Future Networking Solutions

## Meeting future computing & comm. demands

### Impact of Optical Supercomputing

As processing power and networks become faster, cheaper and more reliable with the use of optics, more complex calculations can be made and more complex data analysed in less time.


**SOCIAL IMPACT:** Advancements enable more accurate simulation and more detailed analyses of more data points in less time. Results can be used to draw proactive conclusions, e.g. from simulations and analyses of physical or security data, in order to protect society against natural disasters or health epidemics. By removing the switch from electrical to optical technologies, possible cyber attacks can be avoided.[1]


**ECONOMIC IMPACT:** With the increasing adoption of Big Data analytics, companies require more powerful systems.[2] Accordingly, sales of supercomputers rose 65% from 2009 to 2010 and 29% between 2011 and 2012.[3] The intricate design of products as well as advances in research will lead to better-quality products3 that can be produced faster and cheaper.[4]

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

[1] Techradar.com (2012), [2] Network Computing (2013) , [3] National Research Council (2005), [4] Georgia Tech (2013)





## Affected Action Lines

### Future Cloud


Progress in developing optical devices makes computing units not only cheaper and smaller but also faster and more secure. Processing speeds rise while more and more units can be crammed onto computer chips. The deployment of faster data processing technology will improve reliability and capacity of data centres and backbones. Considering the steadily increasing use of cloud services, big data analytics and communication with more and more data involved, this development is of exceptional significance.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Future Networking Solutions


Optical Supercomputing will spur higher data transmission and processing speeds and eliminate the decelerating switch from optical to electrical circuits. Using all-optical devices will help to handle the constantly increasing data traffic over the internet and increase response times of network nodes. Progress in this field will positively affect the reliability of internet services. Since distance does not matter with optical fibre, networks will become easier reconfigurable and scalable, and client/server and P2P architectures could be disrupted.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

## All-Opt. Networks: Use Case for FNS

### Description


The deployment of fibre-optical networks is becoming more common. As most of contemporary network devices are using electrical circuits though, a switch between light and electrical current is necessary at the nodes of a network. However, each switch represents a bottleneck in data transmission, leading to a decreased bandwidth. While data traffic over the internet is steadily growing, solutions to increase bandwidth are urgently needed.

Being able to manufacture all-optical devices would help to overcome the decelerating switch between optical and electrical circuits and thus increase bandwidth. Light will travel through telecommunication lines and will directly be processed in optical computers. Since heat will be reduced and there is no distortion between separate light signals, more optical devices can be crammed into tinier spaces on computer chips. Processing speeds will rapidly accelerate, which also leads to a higher bandwidth, particularly regarding data centres and cloud services.

Considering that, all-optical devices will contribute to an advanced handling of the exploding data traffic over the internet and also increase connectivity. Better connectivity and higher data transmission speeds result not only in more reliable services but might also lead to changes in network design.

### Control Light in semiconductor nano-crystals

A step towards an optical transistor has been made by developing a method to control light in the semiconductor nano-crystals. Using optical transistors could accelerate processing light signals transmitted through fibre-optic lines in electronic devices.

### Tiny-point-of-light-emitting waveguide

A new tunnel-like device can focus light into tinier spaces and hence squeeze more data through optical fibres. It can channel light in three dimensions, using only half of the light that is sent through and thereby increasing bandwidth.

# Rural Connection

## Integrating rural users into global networks.

While the number of internet connections, the internet speed as well as mobile penetration in urban areas rise constantly, rural regions still suffer from a lack of connectivity. In fact, two-thirds of the world's population does not yet have internet access.1 There are many economic challenges to close this gap. However, new approaches are aiming to create feasible solutions to resolve this problem.

In the last months, specific technologies aiming to modernise the rural economy have emerged. Progress has already been made to provide rural areas with affordable broadband via unprecedented approaches such as balloons and Wi-Fi mesh networks. Furthermore, technology advancements enable alternative supply chains that do not require human intervention or costly infrastructure.

With access to connectivity and low cost offerings, fundamental services such as education and healthcare will be radically different in the future.

### Related Trends

- Automated Tele-Diagnostics
- Drone Networks
- P2PCellular Networks
- Low-Cost Computing

### Affected Action Lines

- Health and Well-being
- Future Urban Life & Mobility
- Future Networking Solutions

## Modernisation is key for rural areas' future socio-economics

### Impact of Rural Connection

The introduction of new technologies will allow rural areas to transition into a more productive socio-economic sector.


**SOCIAL IMPACT:** Development of rural areas contributes to the quality of life of society as a whole, because they contain important public or quasi-public goods, such as clean environments, attractive landscapes and cultural heritage. Modernising and connecting these areas will be a key component towards closing income gaps, combating climate change, shifting towards renewable energies, and catering global food demands.[1]


**ECONOMIC IMPACT:** Availability of low-cost devices and connectivity will improve the competitiveness of rural businesses. New technologies, along with proper policy, will accelerate expansion of rural regions in new economic sectors with high investments such as renewable energy. Thus, connecting the rural world will increase capital flows and provide them with a bigger, more important role in the global economy.[1]

**Time-to-market** | < 3 Years | **3 – 5 Years** | > 5 Years

[1] Google Research (2013)





## Affected Action Lines

### Health and Well-being


Shortage of doctors in remote places will be addressed by intelligent but affordable low-cost teleconference solutions. Patients will be able to get basic medical attention and an initial diagnostic screening by using a TV, a video gaming console, an internet connection and an intelligent software.

**Time-to-market** | **< 3 Years** | 3 – 5 Years | > 5 Years

### Future Urban Life & Mobility


A network of flying drones will distribute supplies across areas where road infrastructure is not reliable. The drones will be powered by batteries and can be recharged at ground-based stations. This system will be so easy to use that it will be accessible for anyone.

**Time-to-market** | < 3 Years | 3 – 5 Years | **> 5 Years**

### Future Networking Solutions


Unconventional technologies like balloons, TV signals, mesh wireless networks as well as low-cost devices will be responsible for connecting the unconnected. Telephony services and ultra fast internet access will be available to remote areas without cell towers and land lines.

**Time-to-market** | < 3 Years | **3 – 5 Years** | > 5 Years

## Drone Networks: Use Case for ULM

### Description


Transportation allows collaboration and trade across regions. Current transportation systems are capital intensive or unusable in specific terrains, making it challenging for developing countries to provide a proper transportation infrastructure. But a new paradigm for transportation is emerging: A mesh network of unmanned drones. The network has three key components: drones, custom-built autonomous quad-copters with GPS and sensors, a network of solar-powered charging stations for the drones to charge batteries and an OS to orchestrate the drone web.

Applications for this network are vast. For instance, a network of flying drones could deliver medications fast, improving living standards and reducing distribution costs. The same network could also be used as the rural post-/short-haul logistics services, expanding the reach of rural workers and businesses.

A startup has developed a prototype which has been tested in Haiti, delivering supplies to camps set up in the wake of the 2010 earthquakes. While plans for wider testing exist, there are main difficulties in terms of regulations. In the majority of countries, the air space for flying drones is yet to be regulated. Hence, advancements in technology along with regulation will be necessary to ensure its proper use, avoid the illegal traffic of goods, and make this a safe use case for society.

### Control Light in semiconductor nano-crystals

A startup is currently developing a short-distance delivery service that uses a network of unmanned drones to distribute supplies. A current prototype can transport over 2Kg of load within 15 minutes.

### Tiny-point-of-light-emitting waveguide

Airware develops autopilots for drones. Their platform allows users to create unique unmanned aerial systems for specific applications while maintaining the basic functionality of the autopilot.

# Virtual Currency
## A new market heavily attracts investors.

Virtual currencies are global and decentralised digital currencies that are secured based on cryptographic proof. They are not backed by government-owned central banks or national currencies and therefore independent from intermediaries. Virtual currencies allow parties to transact freely across borders.

To date, several startups focus on developing technology solutions around creating, managing, securing and transacting with virtual currencies, opening new opportunities, especially in mobile payments. Current approaches address emerged hurdles regarding user friendliness, legality, currency volatility and overall acceptance.

Recent financial crises that were linked to risky bank investments and led to government interventions on private fortunes have driven private and business investors to the virtual currency Bitcoin. This virtual currency may not be the final future solution, but the advancements in related technology will pave the way for further developments in the space.

### Related Trends

- Encryption Technologies
- Digital Economy
- Open Transact.+BitMessage
- Distributed Supercomputing

### Affected Action Lines

- Future Cloud
- Privacy, Security & Trust

## Democratising established financial structures

### Impact of Virtual Currency

Virtual currencies will create a deregulated financial environment that will radically change society, especially the financial services industry.


**SOCIAL IMPACT:** Virtual currencies will provide an alternative for the unbanked. International money transfers will become easier and cheaper. Since these currencies are not backed by governments, they pose serious challenges in terms of security and tax regulation. They also open the door to new schemes of money laundering which will need to be addressed in case these currencies reach critical mass.


**ECONOMIC IMPACT:** At the moment, the total value of Bitcoins in the market is $1.2bn. Once the virtual currency market reaches mass adoption, it will result in revenue loss for banks and governments and these industries will need to perform structural changes in order to handle such financial disruption.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|





## Affected Action Lines

### Future Cloud


Innovative cloud services will enable the future adoption of virtual currencies in two ways. Firstly, crypto-currencies like Bitcoin can be created faster, cheaper and more efficiently by providing access to distributed computing power. Secondly, a secure cloud storage service will become a prerequisite for the overall establishment of virtual currency as accepted payment option – especially within the context of mobile payment solutions.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Privacy, Security & Trust


The rise of virtual currencies challenges payment service providers as well as government institutions. Future issues around the currency will include virtual money laundering, tax evasion and hacking of private accounts. Technology solutions to deal with transparency and security issues need to be found.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

## Encryption Technologies: Use Case for PST

### Description


One of the biggest challenges for adopting virtual currencies like Bitcoin are security and trust issues. In fact, the Bitcoin economy has received many hits on those fronts. In May 2013, public entities shut down Bitcoin payment platforms like Dwolla Payment Service due to money laundering and tax fraud concerns.1 Also, Bitcoin exchanger Mt.Gox got hacked in June 2011 facing losses of 2000 Bitcoins (equivalent to approx. $50,000).2 In order to become a prevalent monetary system, it is absolutely necessary to find an effective way to secure it.

Virtual currencies such as Bitcoins, are irreversible and anonymous. Once a transaction is completed, it cannot be reversed. If a Bitcoin disappears, there is almost no way to identify the theft. The tiniest security gap could already result in a big risk.

New startups and the open source community are attempting to tackle these hurdles by providing innovative solutions and improve the security of Bitcoin wallets, for instance by creating wallet management platforms or enterprise grade Bitcoin storage solutions. Other startups are developing solutions to embed additional information or attributes to the coins as a way to increase transparency and build trust.

### Colored Bitcoins

A set of Bitcoins can be distinguished from others by tracking their specific origin and "coloring" them. These coins have a different value compared to their underlying Bitcoins. Colored coins could be used as alternative financial instruments in order to trade different values.

### Secured storage of an $3M Bitcoin fund

Data security is of crucial importance to Exante's Bitcoin hedge fund. A comprehensive package of security measures using encryption, storage, pass-word cryptography and multi-signature transaction reflects the state of the art for securing virtual currency.

# Wearable Tech
## Connected life attached to the human body.

The ability to incorporate technology into everyday clothes and accessories opens up a variety of scenarios enriching and simplifying each individual's work and lifestyle.

Designers are creating apparel, accessories, fitness and health wear that can do everything from monitoring heart rate, measuring calorie consumption, charging smartphone batteries, checking into a place with a social network to augmenting someone's reality.

While solutions, like intelligent watches, jackets or glasses have been already introduced, manufacturers are aware that the space on the human body is limited, leaving them the challenge to find the best places where innovative gadgets can be strapped to, worn, or even hung. A wide variety of successful product ideas and solutions are emerging, especially within the health, infotainment and military industries.

### Related Trends

- Embedded Wireless Networks
- User-Machine Interface
- Sensor And Microelectronics
- Power Source Optimisation

### Affected Action Lines

- Cyber-Physical Systems
- Health and Well-being
- Smart Energy Systems


The human body as part of the Internet Of Things

### Impact of Wearable Tech

Wearable technology will increase efficiency for consumers and businesses. However, it will also pose challenges to society in terms of an increase in transparency.


**SOCIAL IMPACT:** Connecting people with the digital environment facilitates daily habits and activities, e.g. health & fitness monitoring, infotainment, or social interaction. Nevertheless, the comprehensive tracking of real-time data leads to an extensive increase in transparency, which is referred to as 'lifelogging' and/or 'quantified self'. Managing and protecting the access to personal information will become a future challenge.[1]


**ECONOMIC IMPACT:** 2014 is expected to be the starting point of wearable devices' success story. Forecasts expect a global retail market value of almost $6bn in 2017, mainly driven by customer demand from North America, Western Europe, the Far East and China. In order to ensure market success, critical technical components need to be enhanced in terms of reliability, durability and size.[2]

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

[1] Thenextweb.com (2013), [2] Juniper (2013)





## Affected Action Lines

### Cyber-Physical Systems


There is a variety of smart ways of connecting the human body with the virtual world. Accelerometer, digital compass, GPS, image and speech recognition technologies or micro-electro-mechanical systems embedded in clothes, accessories, lenses and even tattoos collect and transfer data to other devices and web analytics platforms.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Health and Well-being


Self-administered wearable devices allow patients individual sensor-based health monitoring. Data can be analysed online or on the phone. Advanced medical devices will be created by companies as part of a specific mHealth ecosystems such as remote patient monitoring systems.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

### Smart Energy Systems


Energy produced by a human being's body could be harvested and used to charge electronic devices. Thus, the presently insufficient performance rate of power sources could be compensated in order to increase customer experience.

| Time-to-market | < 3 Years | 3 – 5 Years | > 5 Years |
|---|---|---|---|

## User-Machine Interface: Use Case for HWB

### Description


To date, if a person notices certain symptoms, he consults a doctor. The physician derives a one-time "most likely" diagnosis from the examination results and administers a suitable treatment, whose effectiveness is checked at specific intervals. This is often described as a trial-and-error medicine.[1]

To enable reliable self-diagnoses and remote patient monitoring during treatments, real-time body condition tracking solutions are needed. Thus, people could discover health abnormalities earlier and doctors could make more precise and individually tailored decisions on treatment measures based on data with higher quantity and quality. Overall, health care quality would increase significantly. The market need for such solutions is increasing steadily. Remote patient-monitoring devices have the fastest growing revenue of any medical device sector and offer inexhaustible space for innovation.[2]

Startups and medium-sized companies combine several user-machine interface technologies, like micro- or nano-electro-mechanical systems, to build user-friendly remote patient monitoring systems. Remote treatment systems would be the next step, allowing doctors and even machines to control patients treatments remotely.

### Control Light in semiconductor nano-crystals

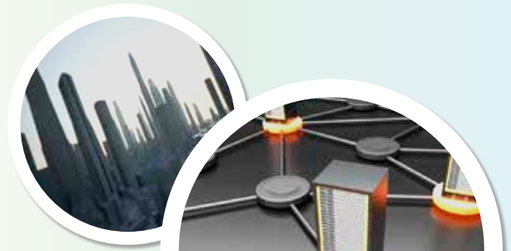
Proteus' system includes three components: a swallowable ingestible sensor packaged within a pill, a smart bandage and a mobile device. Sensor signals are received by the smart bandage and uploaded to the patient's mobile device to be monitored or even shared.

### Tiny-point-of-light-emitting waveguide

Nokia has filed a patent for a magnetic, vibrating tattoo or a badge that alerts users when their phones are ringing. The device would be able to detect a magnetic field and transfer a stimulus to the user. It could be used to notify users of any event happening.

[1] Harvard Business Review (2007), [2] Kalorama Information, (2011)

# **CONCLUSION** – UNDERSTANDING THE ICT TRENDS AND THEIR POTENTIAL IMPACT





In **FUTURE CLOUD** we've seen security in the enterprise world, optical computing and virtual currencies like Bitcoin as the main activities.

Machine learning algorithms, tattoos and patches with electrical components and networks of sensor are the overarching trends of **CYBER-PHYSICAL SYSTEMS**.

**FUTURE URBAN LIFE AND MOBILITY** will be supporting people with physical disabilities, autonomous vehicles, and virtual workforces.

New ways to discover drugs, improvements of patient monitoring, and the shortage of doctors are solutions in the **HEALTH & WELL-BEING** space that could be solved by ICT technologies.

New technologies for **FUTURE NETWORKING SOLUTIONS** reveal a future of ultra fast connectivity without using conventional infrastructure, allowing remote areas to get connected.

Recent **PRIVACY, SECURITY & TRUST** developments in information systems are starting to protect the corporate world and society against threats rising from BYOD policies and gaps in virtual currencies systems.

Regarding **SMART ENERGY SYSTEMS**, we've seen collaborative activities in society to 'crowd-fund' smart and green energy projects creating alternative financing vehicles for this industry.

Lastly, technologies are enabling people to be able to interact with their environments in **SMART SPACES** via numerous interconnected sensors and intelligent systems. In a few years we expect to see these environments 'awake'.



# APPENDIXES

# **Appendix I**
# Topic/ Technology Advancements List

| Topic/Technology Advancement Title | Thematic Action Lines | | | | | | | | Keywords |
|---|---|---|---|---|---|---|---|---|---|
| | Future Cloud | Cyber-Physical Systems | Future Urban Life & Mobility | Health & Well-being | Future Networking Solutions | Privacy, Security & Trust | Smart Energy Systems | Smart Spaces | |
| Connected Home Solutions | × | × | | | | | | × | Wireless Sensor Network, Cloud, Connected Home |
| Multi-Touch Smart Floor | | × | | | | | | × | Wireless Sensors, Multi-Touch |
| Mobile Workforces | × | | × | | | | | | Mobile, Virtual Workforces, Crowdsourcing |
| Outsource Your Errands | × | | × | | | | | | Virtual Workforces, Mobile, Marketplace, Crowdsourcing |
| Wi-Fi Gesture-Controlling | | | | | × | | | × | Wi-Fi, Motion Control, Interactive, User-Interface |
| Shape-Shifting Devices | | | | | × | | | | Touch, Shape-Shift, Interactive, User-Interface |
| Behavioral Analytics Platform | | × | | × | | | | | Machine Learning, Sensors, Analytics, Algorithm |
| Software To Discover Drugs | | | | × | | | | | Analytics, Deep Learning, Algorithm |
| HTML5 Representation of Confidential Data | × | | | | × | × | | | Cloud, Virtualisation, Mobile, Security |
| Detached Workspace On Smartphones | | | | | × | × | | | Virtualisation, Container, App, Security |
| Secure Microkernel | | | | | | × | | | Microkernel, Security, Smartphone, Virtualisation |
| Formal Verification Of An OS Kernel | | | | | | × | | | Microkernel, Isolation, Smartphone, Security |
| Drone Network | | | × | | | | | | Drones, Network, Transport, Autopilot |
| Operating System For Drones | | | × | | | | | | OS, Drones, Autopilot |
| Colored Bitcoins | | | × | | | × | | | Bitcoin, Virtual, Currency, Security |
| Secured Storage Of $3M Bitcoin Fund | | | | | | × | | | Bitcoin, Security, Encryption |
| Smart Pill | | × | | × | | | | | wearable, User-Machine-Interface, sensors, mobile |
| Vibrating Tattoo | | × | | × | | | | | mobile, wearable, User-Machine-Interface, magnetic |
| Wi-Fi Through TV White Spaces | | × | × | | × | | | | access network, TV, asset light infrastructures |
| Frequency Spectrum Optimisation | | | | | × | | | | predictive analytics, frequency spectrum optimisation, mobile devices, network access |
| Self-Healing Integrated Chips | | × | × | × | | | × | × | mesh networks, sensors, sensor network |
| Microchip That Radiates Terahertz Waves | | × | × | × | | × | | × | microchips, terahertz signals, mobile |
| Tiny-Point-Of-Light-Emitting Waveguide | × | | | | × | | | | nano, photonics, optical semiconductors |
| Laser-Like Photons From Solid-State Chips | × | × | | | × | | | × | photon de-coherence, quantum bit, distributed quantum network |
| 3D Microchip | × | × | | | × | | | × | semiconductors, spintronic chips, in-chip storage, mobile |
| Long-Life Mobile Fuel Cell | | × | × | × | | | × | × | long-lasting fuel cells, mobile devices |
| Control Light In Semi-Conductor Nano-Crystals | × | | | | × | | | | optical, transistors, semiconductor, nano, all-optical, modulation, quantum computing, core, network |
| Nano-Scale Router for Optical Infrastructures | × | | | | × | | | | all-optical, transistors, plasmonic coupler, polarisation-sensitive, surface plasmon polaritons, core, network |
| Economical Filters for Cognitive Radio Systems | | × | | | × | | | × | frequency isolation, spectrum optimisation, low-cost equipment, access network |
| Physical Keyboard For Touch-Screen Devices | | × | × | | | × | | × | mobile, super-smartphone, advanced interfaces |
| Control Motion Of Magnetic Domains | | | | | × | | × | | magnetism, materials, data storage, energy saver |





| Topic/Technology Advancement Title | Thematic Action Lines | | | | | | | | Keywords |
|---|---|---|---|---|---|---|---|---|---|
| | Future Cloud | Cyber-Physical Systems | Future Urban Life & Mobility | Health & Well-being | Future Networking Solutions | Privacy, Security & Trust | Smart Energy Systems | Smart Spaces | |
| Increase Distance Signals Travel Over Optical Fiber | | | | | × | | | | Kerr nonlinearity limit, light distortions, high data rate, long distance, optical, fiber, networks, core |
| New Sensitive Microphone | | × | × | | × | × | | × | micro-eletrochemical microphones, audio systems, optical sensors, next generation sensors, mobile |
| Highly Integrated Millimeter-Wave Transceiver | | × | × | × | × | | | | phased-array transceivers, high data-rate communications, polarised antennas, access networks |
| Temporal Cloaking to Hide Fiber Optic Data | | | | | × | × | | | security, optical telecommunications |
| New Type Of Transparent Electrode | | | × | | × | | | × | flexible, electronics, opto-electronic circuits, nano, mobile |
| Moving Robotic Touch Screen | | × | × | × | × | | | × | touchscreen, interface |
| Virtual Tele-Medical Assistant | | | | × | | | | | remote diagnosing tools, telemedicine, mobile, augmented reality, body and speech recognition |
| Narrative Structures From Data Analyses | | × | × | × | | | × | × | artificial Intelligence, data interpretation, machine learning |
| Smart Energy Crowdfunding | | | × | | | | × | | solar energy, crowdfunding |
| P2P Car Sharing | | | × | | | | | | Collaborative Consumption, car, cental, sharing |
| Emotion Analytics | × | | × | × | × | × | | × | machine learning, speech recognition, real-time analytics, intonation analysis |
| Content Delivery Through Sound Waves | × | | × | | | × | | × | mobile, advertising, location-based |
| Novel Silicon Electrodes That Improve Lithium-Ion Batteries | | | | | | | × | | lithium-ion, nano, mobile, battery |
| Programming Model for Future Supercomputers | × | | | | × | | | | Global Address Space, programming, interface, supercomputing, distributed storage |
| Self-Charging Cell Phone Screen | | | × | | | | × | × | mobile, renewable, energy |
| 3-D-modelling Using Microphones | × | | | × | × | | | × | mobile, super-smartphone, advanced interfaces, 3D printing |
| Street Sign Plugged Into Social Media | | × | × | | × | | | × | social Media, smart cities, connected infrastructure |
| Augmented Reality Helmet | | × | × | | × | | | × | augmented reality, interfaces, mobile |
| Operating System For Buildings | | × | × | | | | × | × | smart city, predictive analysis |
| POS Using Facial Recognition | | | | | | × | | × | mobile commerce, Retail 2.0, POS |
| Crowdsourced Traffic Optimisation | | | × | | | | | × | crowdsourcing, traffic, road, driving, mobile |
| Thin Servers with Small Pipes | × | | | | × | | | | server architectures, low-power processors, memcaching, traffic offloading |
| Smart Bins | | | | | | | | × | connected infrastructure, connected cities |
| Smart Pavement | | | | | | | | × | connected infrastructure, connected cities |
| Real-Time Operational Intelligence | × | | | × | | | × | | big data, analytics |
| End-To-End Data Analytics | × | | | × | | | × | | big data, analytics |
| Elastic Log Processing & Log Reduce | × | × | × | | | | × | | big data, analytics, M2M |
| Biologically Inspired Machine Learning | × | | | × | | | × | | big data, analytics, real-time analytics |
| At-Home Disease Diagnosis Systems | × | | | × | | | | | big data, analytics, smart diagnostics |
| Transistors Without Semiconductors | | | | | × | | × | | nano, quantum computing, semiconductors, energy saving |
| Streamloading | | | | | × | | | | big data, traffic offloading, access, network |
| Ferroelectric-Graphene-Based System To Improve Information Processing | | | | | × | | × | | all-optical, networks, optical transistors, core |
| Telescopic Contact Lens | | | × | × | × | | | | wearable, mobile, User-Machine-Interface, lens |
| Smart Glasses | | | × | × | | | | | wearable, mobile, User-Machine-Interface, glasses |
| Cloud Bitcoin Mining | × | | × | | | × | | | Bitcoin, Virtual Currency, payment, money, Cloud Computing |
| Bitcoin Economy Solutions | × | | × | | | × | | | Bitcoin, Virtual Currency, payment, money |

| Topic/Technology Advancement Title | Thematic Action Lines | | | | | | | | Keywords |
|---|---|---|---|---|---|---|---|---|---|
| | Future Cloud | Cyber-Physical Systems | Future Urban Life & Mobility | Health & Well-being | Future Networking Solutions | Privacy, Security & Trust | Smart Energy Systems | Smart Spaces | |
| Balloon Wi-Fi | | | | | × | | | | internet access, balloons |
| 5D data storage | × | | | | | | | | storage, optical |
| Graphene Radio Transmission | | | | | × | | | | graphene, signal processing |
| Green Gamification | | | | | | | × | × | gamification, green, mobile |
| Deep Links | | | | | | | | × | mobile, advertising, apps, interoperability |
| Opportunistic Mobile Networks | | | | | × | | | | mobile, wireless, optimisation |
| In-Air Signature | | | | | | × | | × | security, mobile, gesture |
| ArkOS | × | | | | | | | | server, OS, open source, cloud |
| Computational Creativity | × | | | | × | | | | big data, analytics, computation |
| 802.15.4e | | × | | | × | | | | wireless, standardisation, Internet of Things |
| Safety CCTV | × | | | | × | × | | | surveillance, cloud, security |
| Seamless Network Integration | | | | | × | | | | content delivery |
| Upstream filtering for cyber security | | | | | | × | | | security, filtering |
| Homomorphic Encryption in the cloud | × | | | | | × | | | cloud, encryption, security |
| Hyperscale Computing | × | | | | | | | | hyperscaling, parallel processing |
| Medical Steganography | | | | × | | × | | | privacy, medical, patient data |
| Micro-Satellite Cameras | | | × | | | | | × | satellite, observation, traffic |
| P1901.2 - Smart Grid powerline Communication | | × | | | × | | × | | smart grid, connected home, access |
| Spectrum Refarming | | | | | × | | | | mobile, cellular, optimisation |
| Tiled Streaming | | | | | × | | | | streaming, video, high quality |
| Internet-of-Things gateway standard | × | × | | | | | | | Internet of Things, standardisation, cloud |
| Google AdID | | | | | | × | | | tracking, privacy, security, advertising |
| Multipath TCP | | | | | × | | | | TCP, standardisation |
| Medical device encryption | | | | × | | × | | | encryption, privacy, security, implants |
| Brainwave identification for drivers | | | × | | | × | | | security, automotive, biometrics |
| Car-Net | | × | × | | × | | | | connected vehicles |
| APS Standard | × | | | | | | | | cloud, distribution, standardisation |
| ECG biometrics | | | | | | × | | × | security, biometrics |
| Vehicle-to-Pedestrian | | × | × | | | | | | mobile, safety, automotive |
| Visual Merchandising | | × | | | | | | × | location, shopping, logistics, visualisation |
| Energy Harvesting MEMS | | × | | | | | | × | energy, self-sustained |
| frame aggregation for Wi-Fi | | × | | | × | | | × | wireless, standardisation, energy efficiency |
| RPL - IPv6 Routing Protocol for Low-Power and Lossy Networks | | × | | | | | | | standardisation, Internet of Things, sensors, connectivity |
| Airborne Base Stations for Emergency and Temporary Events | | | | | × | | | | emergency, access |
| Vital Data photo tagging | | | | | × | | | | sensor, tagging, photo, vital data |
| The Serval Project | | | | | × | | | | mesh, emergency, access |
| Mobile phone quantum cryptology | | | | | | × | | | mobile, security, quantum, encryption |
| Leap Motion 3D Control | | | × | | | | | × | gesture, control |
| Seamless Authentication | | | | | | × | | | authentication, security, mobile |
| Enterprise Mobile Services SDKs | × | | | | | | | × | SDK, development, enterprise, mobile |
| In-memory computing | × | | | | | | | | enterprise, database, big data, performance |
| TouchBase | | × | | | | | | × | mobile, digital code, proximity |
| Cognitive Protocols | | | | | × | | | | mesh, routing, optimisation |





| Topic/Technology Advancement Title | Thematic Action Lines | | | | | | | | Keywords |
|---|---|---|---|---|---|---|---|---|---|
| | Future Cloud | Cyber-Physical Systems | Future Urban Life & Mobility | Health & Well-being | Future Networking Solutions | Privacy, Security & Trust | Smart Energy Systems | Smart Spaces | |
| Millimeter waves | | × | | | × | | | | mobile, 5G, transceiver |
| polyurethane | | | | × | | | | | flexible electronics |
| webinos | | | | | | | | × | interoperability, browser, OS |
| Wood fiber batteries | | | × | | | | | | electric vehicles, battery |
| Optical transistors | | | | | × | | | | all-optical, transistor, photonics, laser |
| QUIC | | | | | × | | | | protocol, optimisation |
| 3D Scanning & Printing Communities | | × | | | | | | | 3D printing, mass customisation, digitisation |
| Smart Farming | | × | | | | | | | farming, satellite, optimisation |
| A4WP | | | | | | | | × | wireless power, devices, charging, alliance, standardisation |
| Resilient mobile networks | | | | | × | | | | resilience, roaming, mobile |
| Group Call Service Enablers in LTE | | | | | × | | | | 4G, LTE, group call |
| Railgun Protocol | × | | | | × | | | | optimisation, protocol, cloud |
| Zopfli | | | | | × | | | | compression, optimisation |
| Automatic content recognition (ACR) | | | | | | | | × | analytics, media |
| Protected Core Networking | | | | | × | × | | | communication, military |
| Signalling storm in mobile networks | | | | | × | | | | mobile, optimisation |
| DSP in high performance computing | × | | | | | | | | processing, energy efficiency, performance |

# **Appendix II**
# Topic/Technology Advancements Ranking

## Topic/Technology Advancements Ranking for CLD*

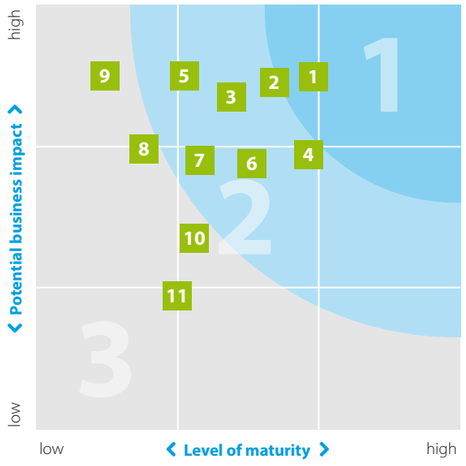

RANK **TOPIC / TECHNOLOGY ADVANCEMENTS**

1. Real-Time Operational Intelligence
2. Connected Home Solutions
3. Biologically Inspired Machine Learning
4. Emotion Analytics
5. Elastic Log Processing & Log Reduce
6. Cloud Bitcoin Mining
7. HTML5 Represent. of Confidential Data
8. Mobile Workforces
9. Outsource Your Errands
10. End-To-End Data Analytics
11. Bitcoin Economy Solutions

Technology Service **1/2/3** Priority

* Selection of most relevant 'Topic / Technology Advancements'. Ranked topics are clickable in presentation mode.

## Topic/Technology Advancements Ranking for CPS*




RANK **TOPIC / TECHNOLOGY ADVANCEMENTS**

1. Connected Home Solutions
2. Behavioural Analytics Platform
3. Narrative Struct. from Data Analyses
4. Operating System For Buildings
5. Smart Pill
6. Street Sign Plugged Into Social Media
7. Multi-Touch Smart Floor
8. Self-Healing Integrated Chips
9. Economical Filters For Cog. Radio Syst.
10. Augmented Reality Helmet
11. Augmented Reality Helmet

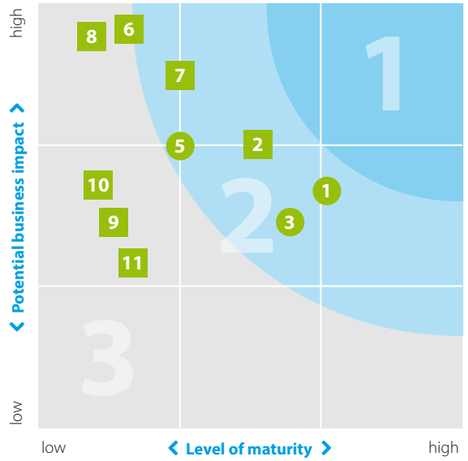
Technology Service **1/2/3** Priority

* Selection of most relevant 'Topic / Technology Advancements'. Ranked topics are clickable in presentation mode.





## Topic/Technology Advancements Ranking for ULM*



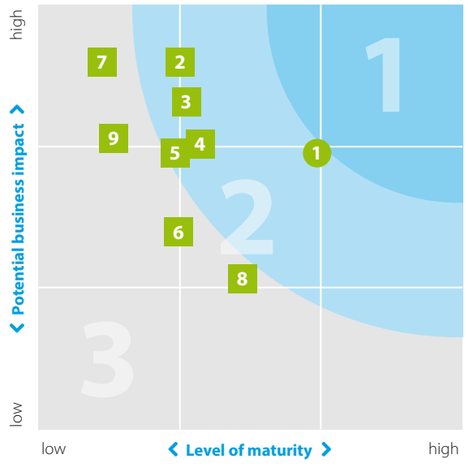

RANK **TOPIC / TECHNOLOGY ADVANCEMENTS**

1. Content Delivery Through Sound Waves
2. Street Sign Plugged Into Social Media
3. Outsource Your Errands
4. Operating System For Drones
5. Mobile Workforces
6. Drone Network
7. Coloured Bitcoins
8. Shape-Shifting Mobile Devices
9. Microchip that radiates terahertz waves
10. New type of transparent electrode
11. Wi-Fi Through TV White Spaces

Technology Service **1/2/3** Priority

* Selection of most relevant 'Topic / Technology Advancements'. Ranked topics are clickable in presentation mode.

## Topic/Technology Advancements Ranking for HWB*



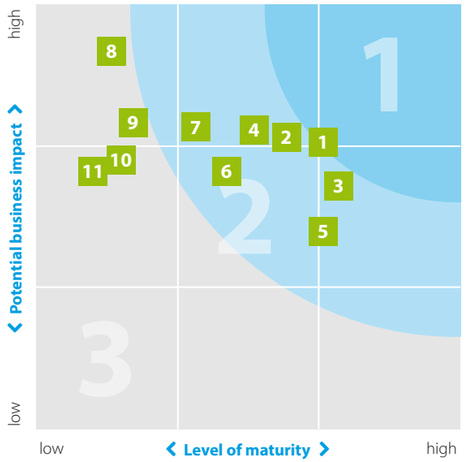

RANK **TOPIC / TECHNOLOGY ADVANCEMENTS**

1. Virtual Tele-Medical Assistant
2. Behavioural Analytics Platform
3. Telescopic Contact Lens
4. Smart Pill
5. At-Home Disease Diagnosis Systems
6. Vibrating Tattoo**
7. Software To Discover New Drugs
8. Smart Glasses***
9. Microchip Radiates Terahertz Waves****

Technology Service **1/2/3** Priority

* Selection of most relevant 'Topic / Technology Advancements'. Ranked topics are clickable in presentation mode. / ** as an enabler, e.g. for implants / *** e.g. for training of medics, guiding surgeons, providing patient information, supporting visually impaired users in identifying objects / **** e.g., as a substitute for X-rays

## Topic/Technology Advancements Ranking for SSP*

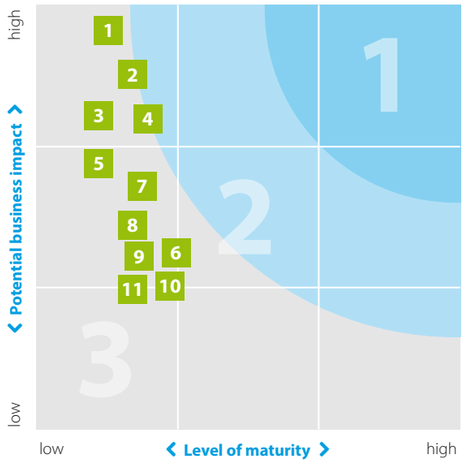



| RANK | TOPIC / TECHNOLOGY ADVANCEMENTS |
|---|---|
| 1. | Connected Home Solutions |
| 2. | Operating System For Buildings |
| 3. | Smart Bins |
| 4. | Street Sign Plugged Into Social Media |
| 5. | POS Using Facial Recognition |
| 6. | Smart Pavement |
| 7. | Multi-Touch Smart Floor |
| 8. | Shape-Shifting Mobile Devices |
| 9. | Gesture-Controlling Technology |
| 10. | New Type Of Transparent Electrode |
| 11. | Keyboard For Touch-Screen Devices |

Technology Service **1/2/3** Priority

* Selection of most relevant 'Topic / Technology Advancements'. Ranked topics are clickable in presentation mode.

## Topic/Technology Advancements Ranking for FNS*




| RANK | TOPIC / TECHNOLOGY ADVANCEMENTS |
|---|---|
| 1. | Shape-Shifting Mobile Devices |
| 2. | New Type Of Transparent Electrode |
| 3. | Moving Robotic Touch Screen |
| 4. | Gesture-Controlling Technology |
| 5. | New Sensitive Microphone |
| 6. | Emotion Analytics |
| 7. | 3D-Modelling Using Microphones |
| 8. | Thin Servers With Small Pipes |
| 9. | 3D Microchip |
| 10. | Augmented Reality Helmet |
| 11. | Wi-Fi Through TV White Spaces |

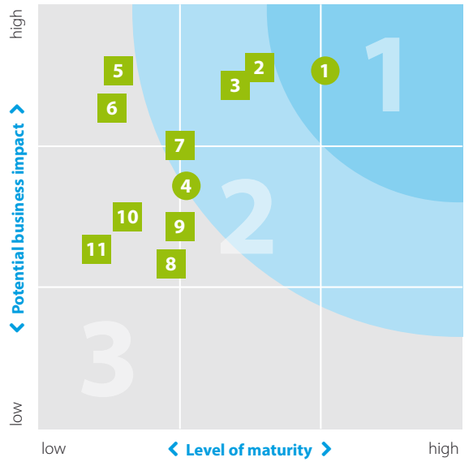
Technology Service **1/2/3** Priority

* Selection of most relevant 'Topic / Technology Advancements'. Ranked topics are clickable in presentation mode.





## Topic/Technology Advancements Ranking for PST*

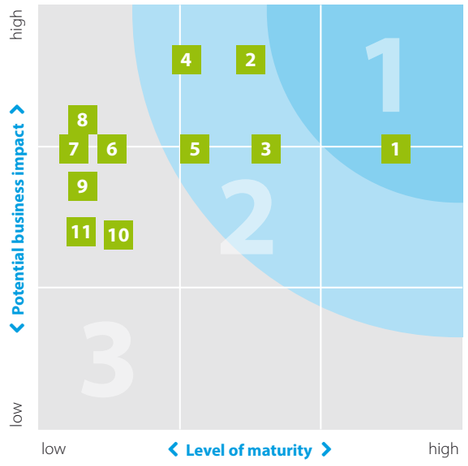



| RANK | TOPIC / TECHNOLOGY ADVANCEMENTS |
|---|---|
| 1. | Secured Storage Of $3M Bitcoin Fund |
| 2. | Secure Microkernel |
| 3. | Formal Verification Of An OS Kernel |
| 4. | Cloud Bitcoin Mining |
| 5. | Microchip Radiates Terahertz Waves |
| 6. | Cloaking To Hide Fibre Optic Data |
| 7. | HTML5 Represent. of Confidential Data |
| 8. | Colored Bitcoins |
| 9. | Detached Workspace On Smartphones |
| 10. | New Sensitive Microphone |
| 11. | Physical Keyboard For Touch-Screens |

Technology Service **1/2/3** Priority

* Selection of most relevant 'Topic / Technology Advancements'. Ranked topics are clickable in presentation mode.

## Topic/Technology Advancements Ranking for SES*




| RANK | TOPIC / TECHNOLOGY ADVANCEMENTS |
|---|---|
| 1. | Real-Time Operational Intelligence |
| 2. | Operating System For Buildings |
| 3. | Elastic Log Processing & Log Reduce |
| 4. | Biologically Inspired Machine Learning |
| 5. | Self-Healing Integrated Chips |
| 6. | Long-Life Mobile Fuel Cell |
| 7. | Silicon Electrodes Improve Lit.-Ion Bat. |
| 8. | Self-Charging Cell Phone Screen |
| 9. | Ferroelect.-Graphene-Based System To Improve Information Proc. |
| 10. | Control Of Motion Of Magnetic Domains |
| 11. | Transistors Without Semiconductors |

Technology Service **1/2/3** Priority

* Selection of most relevant 'Topic / Technology Advancements'. Ranked topics are clickable in presentation mode.

# Appendix III
## Analytical Clustering of identified topics and evaluation of related trends

| Topics/ Technology Advancements* | Technological Breakthrough** | Other Relevant Developments | Overall | Related Trends |
|---|---|---|---|---|
| **Ambient Computing** | | | | |
| 1 2 3 4 +5 | low high | low high | low high | **This trend would not be possible without pervasive connectivity. Hence other related trends involving connectivity are identified: Connected Home, Autonomous Vehicles (which need to be connected), Internet of Things. Also since the ambient will need to intelligently respond to the user Context Aware Technologies are also related.** |
| Amongst others: Connected Home Solutions, Multi-Touch Floor, Sensitive Microphone, Street Sign Plugged Into Social Media, Self-Healing Chip | Applied technologies will boost user experience to a new level, where seamless connectivity along with unobtrusive devices will be predominant. | The Topics/Technology Advancements have a good presence in scientific papers but minor presence in mass media. | A good number of developments in research has shown a clear direction towards ambient computing. | |
| **Collaborative Consumption** | | | | |
| 1 2 3 4 +5 | low high | low high | low high | **The diverse nature and scale of emerging solution within the space create other important trends such as Car Sharing, Real Estate Sharing, Virtual Workforces , and Crowdfunding.** |
| Amongst others: Mobile Workforces, Outsource Your Errands, Crowdsourced Traffic Optimisation, P2P Car Sharing, Smart Energy Crowdfunding | While the core technology is not recent, its application and specificity really is. | Intense M&A activity and VC funding combined with extensive and constant mass media converge around the world. Social movements are appearing. | Intense M&A activity and VC funding combined with extensive and constant mass media converge around the world. Social movements are appearing. | |

* Topics/ Technology Advancements spotted in the last 12 months / **Technical Breakthrough refers to an advance that gives people powerful new ways to use technology. It can be high, medium or low and is based on expert opinion.





| Topics/ Technology Advancements* | Technological Breakthrough** | Other Relevant Developments | Overall | Related Trends |
|---|---|---|---|---|
| **Context-based Interfaces** | | | | |
| 1 2 3 4 +5 | low high | low high | low high | **Attempts to develop smarter software are related to Deep learning, including: Behavioral Analytics Platforms, Self-Programming Software, Search and Semantic Web, Task Automation.** |
| Amongst others: Terahertz-Wave Chip, Shape-Shifting Devices, Gesture-Controlling Technology, Moving Robotic Touch Screen, Augmented Reality Helmet | Deep Learning will enable computers to undertake and automate many tasks that only humans are able to do today. | Significant coverage in the scientific community with some major publications in mass media. Google, CIA and major venture companies have investments in this field. | Besides the fact that technically speaking this is a major development, there is significant activity along with solid investments. | |
| **Deep Learning** | | | | |
| 1 2 3 4 +5 | low high | low high | low high | **Attempts to develop smarter software are related to Deep learning, including: Behavioral Analytics Platforms, Self-Programming Software, Search and Semantic Web, Task Automation.** |
| Amongst others: Narrative Structures From Data Analyses, Emotion Analytics, Real-Time Operational Intelligence, Biologically Inspired Machine Learning, Software to discover drugs | Deep Learning will enable computers to undertake and automate many tasks that only humans are able to do today. | Significant coverage in the scientific community with some major publications in mass media. Google, CIA and major venture companies have investments in this field. | Besides the fact that technically speaking this is a major development, there is significant activity along with solid investments. | |
| **Enterprise Mobile Security** | | | | |
| 1 2 3 4 +5 | low high | low high | low high | **Trends who aim to either improve the security inside an enterprise or increase employee mobility are related. This trends include: Integrated Network Access Control (NAC), Enterprise App Stores, Secure Microkernel Architecture, and On-Demand Mobile Virtualisation.** |
| HTML5 Representation Of Confidential Data , Detached Workspace On Smartphones, Secure Microkernel, Formal Verification Of An OS Kernel | A secure mobile enterprise would be one step further to having a single unified computing device for business and personal use. | Studies suggest that more than 45% of enterprises are increasing their investments in mobile security.[1] | While players in the space are somehow limited, enterprise security is paramount which is creating important investments in this area. | |

* Topics/ Technology Advancements spotted in the last 12 months / **Technical Breakthrough refers to an advance that gives people powerful new ways to use technology. It can be high, medium or low and is based on expert opinion.

[1] MGI Research (2012)

| Topics/ Technology Advancements* | Technological Breakthrough** | Other Relevant Developments | Overall | Related Trends |
|---|---|---|---|---|

## Optical Super-Computing

| Topics/ Technology Advancements* | Technological Breakthrough** | Other Relevant Developments | Overall | Related Trends |
|---|---|---|---|---|
| 1 2 3 4 +5 | low high | low high | low high | **A cheaper but faster hardware is the foundation for the future of computing. This new breed of computers will reduce the communication bottlenecks in All-Optical Networks. Advancements in the field will make SDNs Distributed Quantum Networks and Artificial Intelligence possible. Fast Big Data Analytics will depend also on this technology.** |
| Amongst others: Optical Nano-Scale Router, Tiny Light-Emitting Waveguide, Controlling Light In Semiconduct. Nanocrystals,Increased Travel Distance Of Optical Signals, Transparent Electrode | Unprecedented speeds and ways to analyse big data sets, opening to many opportunities. | Business are increasingly investing in supercomputing architecture to support big data activities. Comprehensive press coverage of these Topics/Technology Advancements. | The activity in the scientific community around these Topics/Technology Advancements and its relevancy for the future of hardware makes this one of the most important trends. | |

## Rural Connection

| Topics/ Technology Advancements* | Technological Breakthrough** | Other Relevant Developments | Overall | Related Trends |
|---|---|---|---|---|
| 1 2 3 4 +5 | low high | low high | low high | **This trend covers a wide spectrum of applications across rural areas, from Automated Tele-Diagnostics, Drone Networks, Peer-To-Peer Cellular Networks to Low-Cost Computing.** |
| Amongst others: Virtual Tele-Medical Assistant, Self-Charging Cell Phone Screen, Wi-Fi Through TV Signals, Wi-Fi Balloons, Dronenet | The introduction of new technologies will allow rural areas to transition into a more productive socio-economic sector. | Sporadic topics such as Google Loon have had important coverage. Internet companies like Google, Facebook and Amazon are heavily investing on this space. | Breakthroughs in this space can have significant spill-over effects in multiple industries such as sustainable energy. | |

## Virtual Currency

| Topics/ Technology Advancements* | Technological Breakthrough** | Other Relevant Developments | Overall | Related Trends |
|---|---|---|---|---|
| 1 2 3 4 +5 | low high | low high | low high | **Virtual currencies are a component of the Digital Economy. Without Encryption Technologies (such as +BitMessage) and Distributed Supercomputing its existence could not be possible.** |
| Colored Bitcoins, Secured Storage Of Bitcoin Fund, Cloud Bitcoin Mining, Bitcoin Economy Solutions | Virtual currencies will create a deregulated financial environment that will radically change society, especially the financial services industry | Over the last quarter there is been a significant interest and investment from the VC community. Important investments have created plenty of buzz. | The latest developments in terms of new startups, investments and press coverage makes a strong case for this trend to emerge. | |

* Topics/ Technology Advancements spotted in the last 12 months / **Technical Breakthrough refers to an advance that gives people powerful new ways to use technology. It can be high, medium or low and is based on expert opinion.





| Topics/ Technology Advancements* | Technological Breakthrough** | Other Relevant Developments | Overall | Related Trends |
|---|---|---|---|---|

## Wearable Tech

| Topics/ Technology Advancements* | Technological Breakthrough** | Other Relevant Developments | Overall | Related Trends |
|---|---|---|---|---|
| 1 2 3 4 +5 | low high | low high | low high | **When people start wearing technology they would need to get connected, creating Embedded Wireless Networks among devices. Wearable technology will drastically change the User-Machine Interfaces, add more Sensor And Microelectronics in the world.** |
| Amongst others: Vibrating Tattoo, Smart Pill, Telescopic Contact Lens, Augmented Reality Helmet, Smart Glasses | Wearable technology will increase efficiency for consumers and businesses. However, it will also pose challenges to society in terms of an increase in transparency. | Wearable technology will increase efficiency for consumers and businesses. However, it will also pose challenges to society in terms of an increase in transparency. | The abundance of players and its importance in the consumer electronic space are clear indicators of this trend. | |

* Topics/ Technology Advancements spotted in the last 12 months / **Technical Breakthrough refers to an advance that gives people powerful new ways to use technology. It can be high, medium or low and is based on expert opinion.

# Evaluation of Related Trends – The occurrence of Related Trends

| General Description | Topics/ Technology Advancements* | Relevant Market Developments | Overall |
|---|---|---|---|
| **Connected Home** | | | |
| Appliances and devices in the home become connected to the internet and to one another. |  Connected Home Solutions, Multi-Touch Smart Floor |  | We see much discussion on this development. However, there are only few mature Topics/ Technology Advancements, which make it only a related trend. |
| **Autonomous Vehicles** | | | |
| Vehicles reach to a level of intelligence that they can drive themselves. |  Drone Networks, OS for Drones, Smart Pavement |  | While this topic is ubiquitously addressed recently, we cannot identify any breakthrough developments, hence this remains a related trend. |
| **Internet Of Things** | | | |
| Equipping all objects in the world with minuscule identifying devices or machine-readable identifiers. |  Connected Home Solutions, Smart Pill |  | Due to its importance in the last years, recent investments and coverage have focus in other topics. Leaving IofT a not-that-relevant trend. |
| **Context-Aware Technologies** | | | |
| Electronic devices become aware of the user's context and use the most natural interface to interact with the user. |  Shape-Shifting Devices, Multi-Touch Smart Floor |  | Only identified a few Topics/Technology Advancements and see relatively little discussion about this development. |

* Topics/ Technology Advancements spotted in the last 12 months





| General Description | Topics/ Technology Advancements* | Relevant Market Developments | Overall |
|---|---|---|---|
| **Car Sharing** | | | |
| In order to decrease costs and fuel consumption, people share cars, resulting in interesting concepts to coordinate that. |  P2P Car Sharing |  | There where not new technologies in this field. Collaborative Consumption encompass this trend since is about sharing underused assets, making this a related trend. |
| **Real Estate Sharing** | | | |
| Similar to the Car Sharing concepts, short-term Real Estate Sharing is on the rise, involving technology to manage coordination. |  |  | There where not new technologies in this field. Collaborative Consumption encompass this trend since is about sharing underused assets, making this a related trend. |
| **Virtual Workforces** | | | |
| Mobile phones, connectivity and platforms make possible for people to share their time and skills. |  Gigwalk, TaskRabbit |  | Collaborative Consumption encompass this trend since is about sharing underused assets (time and skills included), making this a related trend. |
| **Crowdfunding** | | | |
| Mobile phones, connectivity and platforms make possible to get founded by the collective efforts of the crowds. |  Smart Energy Crowdfunding |  | Collaborative Consumption encompass this trend and technologies that leverage the crowds, making this a related trend. |
| **Brain-Controlled Interfaces** | | | |
| People can interact with computers using brain waves as the interface. |  |  | This topic is being covered by the press. However, we didn't identify any recent result in the time frame. |
| **Shape-Shifting Devices** | | | |
| Handheld touch devices are able to shift their shape according to the context they are used in. |  Shape-Shifting Devices |  | This topic does not yet experience significant traction in public discussion and we have identified only one solution. |

* Topics/ Technology Advancements spotted in the last 12 months

| General Description | Topics/ Technology Advancements* | Relevant Market Developments | Overall |
|---|---|---|---|
| **Interactive Entertainment** | | | |
| Entertainment output is influenced by the users through direct feedback |  Moving Robotic Touch Screen |  | The entertainment space has a great opportunity to get disrupted; however, we haven't seen important developments or investments in the last months. |
| **Authentication & Identification** | | | |
| The development of alternative user interfaces will lead to advanced authenti-cation and identification techniques. |  POS Using Facial Recognition |  | This topic clearly is a priority in research. Still, we cannot identify many innovative and mature solutions yet for this to become a trend. |
| **Self-Programming Software** | | | |
| Software will be able to learn and act intelligently enough to be able to be self-programmed. |  POS Using Facial Recognition |  | Area of huge potential. However, current computing power limits is true potential. More computing power is required for these technologies to become major discussion topics. |
| **Search & Semantic Web** | | | |
| More research is being done in looking for techniques to inter-connect data, make it processable and retrievable more easily. |  POS Using Facial Recognition |  | Area of huge potential. However, current computing power limits is true potential. More computing power is required for these technologies to become major discussion topics. |
| **Task Automation** | | | |
| Devices and objects will be able to accomplish tasks without any human interaction in the future. |  Narrative Structures From Data Analyses |  | We can see rather impressive developments in this field but there are still not sufficient for this to become a trend of its own. |
| **Integrated Network Access Control (NAC)** | | | |
| Computer networking solution that uses a set of protocols to define and implement a security IT policies. |  Narrative Structures From Data Analyses |  | Due to controversy in this topic due to its security threats and the fact that the R&D community have not shown any developments in the this period, we consider this as a related trend. |

* Topics/ Technology Advancements spotted in the last 12 months





| General Description | Topics/ Technology Advancements* | Relevant Market Developments | Overall |
|---|---|---|---|
| **Enterprise App Stores** | | | |
| Corporations start to introduce their own branded app stores to their employees. |  |  | We have not identified any significantly innovative solution in this period but definitely see this topic cover by the media. We consider this as a not-that-recent trend. |
| **Secure Microkernel Architecture** | | | |
| Advanced technologies that are creating ultra secured OS architectures. |  Secure Microkernel Formal Verification Of An OS Kernel |  | We believe there has not been numerous developments due to the high fragmentation in hardware of mobile market, which is slowing down the product development cycles. |
| **On-Demand Virtualisation** | | | |
| In order to reduce the overhead of virtualisation, systems are being enabled to switch between native and virtual execution modes on the fly. |  |  | No recent developments and limited academic activity. We explored this area since reaping the benefits of virtualisation without its costs is technically possible and very attractive financially. |
| **All-Optical Networks** | | | |
| Every node and connected devices have optical circuits, turning the network into an optical one. |  Nano-Scale Router for Optical Infrastructures |  | Besided the fact that all optical networks has been around for a while there was only one technology discovered in this field. |
| **Distributed Quantum Networks** | | | |
| Computer networks that communicate data using quantum states through the technique of entanglement via an optical fiber link. |  |  | This topic is very prominent in research rather than in public discussions. We also cannot identify many high-potential solutions in this timeframe |

* Topics/ Technology Advancements spotted in the last 12 months

| General Description | Topics/ Technology Advancements* | Relevant Market Developments | Overall |
|---|---|---|---|
| **Big Data** | | | |
| The collection, storage, processing and analysis of large data sets is still a popular research field. | 1 2 3 4 +5<br>Real-Time Operational Intelligence, End-To-End Data Analytics | low high | Although a few promising innovations can be spotted, this topic has already been existent for some time which is why it is considered a related trend. |
| **Artificial Intelligence** | | | |
| Machines have the ability to precisely simulate the human brain. | 1 2 3 4 +5<br>Real-Time Operational Intelligence, Self-Healing Integrated Chip | low high | There has been many important steps towards AI, however, there is no clear indicator that this is a trend happening in the near future. |
| **Automated Tele-Diagnostics** | | | |
| Instead of doctors conducting investiga-tions, machines and devices are developed to diagnose health problems remotely. | 1 2 3 4 +5<br>Virt. Tele-Medical Assistant, Moving Rob. Touch-Screen | low high | This topic is becoming more popular due to its high impact. In spite of that, we have not identified a reasonable amount of promising innovations. |
| **Drone Networks** | | | |
| A network of driverless flying objects that can automatically make shipments with no human intervention. | 1 2 3 4 +5<br>Drone Network | low high | Although this topic has a huge potential, it still lacks significant R&D efforts to become a separate trend. |
| **Peer-To-Peer Cellular Networks** | | | |
| More alternatives for traditional cellular networks are emerging, amongst others P2P and mesh networks. | 1 2 3 4 +5<br>Drone Network | low high | There few recent developments in this field to become a trend of its own |

* Topics/ Technology Advancements spotted in the last 12 months





| General Description | Topics/ Technology Advancements* | Relevant Market Developments | Overall |
|---|---|---|---|
| **Low-Cost Computing** | | | |
| Existence of low-cost, yet powerful computing devices. | 1 2 3 4 +5 | low high | While past developments triggered additional scouting efforts, no recent developments where found in this field |
| **Encryption Technologies** | | | |
| Technologies that encode data in such a way that eavesdroppers or hackers cannot read it. | 1 2 3 4 +5<br>Bitcoin Fund, Cloaking to Hide Fiber Data | low high | Despite the fact that this field has received press attention, is too broad and applicable to many fields. Hence is fits better as a related trend. |
| **Digital Economy** | | | |
| Economies based on digital technologies such as communications. | 1 2 3 4 +5<br>Bitcoin Fund, Cloaking to Hide Fiber Data | low high | This trend is considered to be not-that-recent trend and all its coverage is considered to be due to its closeness to the emergence of virtual currencies. |
| **Open Transaction +BitMessage** | | | |
| Alternative ways to performed financial transactions. | 1 2 3 4 +5<br>Colored Bitcoins | low high | This trend is considered to be not-that-recent trend and all its coverage is considered to be due to its closeness to the emergence of virtual currencies. |
| **Distributed Supercomputing** | | | |
| Network of super computers components that communicate and coordinate their actions over a network or the Internet. | 1 2 3 4 +5<br>Colored Bitcoins | low high | Distributed computing will emerge when networks increase its bandwidth levels significantly. Hence, currently remains a scouting topic to monitor but is not a current trend. |

* Topics/ Technology Advancements spotted in the last 12 months

| General Description | Topics/ Technology Advancements* | Relevant Market Developments | Overall |
|---|---|---|---|
| **Embedded Wireless Networks** | | | |
| Due to decreased size and increased energy efficiency of sensors and computer chips, they are increasingly embedded into objects. |  |  | Currently remains a scouting topic to monitor but is not a current trend due to low activity. |
| **User-Machine Interface** | | | |
| Machine interfaces to support users in everyday situations. |  |  | Due to the lack of relevant solutions as well as the specificity of the topic, it is regarded as a sub trend. |
| **Sensor & Micro-Electronics** | | | |
| Researchers are making progress in developing smaller and faster devices and chips. |  Smart Glasses, Telescopic Contact Lens |  | Although many research institutes put their focus on this field, there have only been small developments. Besides, this topic is considered too specific for becoming a trend. |
| **Power Source Optimisation** | | | |
| Techniques to optimise energy consumption and power generation are being developed. |  |  | While this topic is highly relevant for other verticals, there are no relevant ICT-related technical advancements to make this a relevant trend. |
| **Software-defined networking** | | | |
| Technologies that allow to shape traffic from a centralised control console without having to touch individual switches, liberating IT infrastructures from particular vendors. |  |  | While there has been constant product launches from players in the industry, there has been limited true technological advancements in this field. SDN is at maturing stage the focus is on scaling the business rather than introducing new technologies. Because of this, SDN is considered a related trend towards the next generation networks. |

* Topics/ Technology Advancements spotted in the last 12 months

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