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EIT ICT Labs Innovation Radar

Annual Report 2012

Insights into promising ICT-related developments and trends

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The European Institute of Innovation & Technology (EIT) has been founded with the aim to foster innovation and competitiveness in Europe by means of networked innovation, EIT ICT Labs focusing on innovation coming from Information and Communication Technologies.

- Facilitation of follow-ups on identified developments and trends by providing a platform for idea development
- Creation of cohesion within KIC and EIT by referencing to internal experts and excellence in future technologies

The Innovation Radar draws collection and assessment of its information from the networked organisation and its stakeholders facilitated by a community of experts, expert workshops, idea competitions, supporting IT tools for collection and interpretation of developments and trends, and dedicated research. Results are presented in a knowledge database, containing developments and trends assessed from an EIT ICT Labs perspective, dedicated Foresight Studies and Technical Reports, as well as an annual Innovation Radar Report, summarising findings from the respective year.

This report presents activities of the Innovation Radar in 2012 as well as an overview of developments and trends observed in that period. 259 such topics have been identified and assessed. Further input from other Innovation Radar activities has been considered in the assessment of developments and trends.

In order to identify promising areas for ICT-related innovation, a dedicated Foresight activity has been initiated within EIT ICT Labs: the Innovation Radar. Foresight provides methods and tools for the identification of environmental changes, the assessment of the implied opportunities and threats, as well as the utilisation of gained insights for decision-making. The complexity of innovation networks such as EIT requires even more guidance and decision support.

Foresight can reveal insights as a basis for such decisions, but also create a hub for collaborative innovation within and beyond the networked organisation. The Innovation Radar has been designed with the following goals:

- Identification of developments and trends in ICT and neighbouring sectors and specifically for defined thematic areas; making available the information to multiple stakeholders by appropriate means
- Identification of innovation opportunities and commercialisation potential; achieving results through involvement of partners and making them available to partners

2. Review 2012

In 2012, the Innovation Radar team organised and participated in a large number of KIC-internal workshops, including the following:

- Expert workshop for the core industrial partners, Berlin CLC, February 2012
- French industrials meeting, Paris, April 2012
- Business circle writers' studio, Sophia-Antipolis, June 2012
- Three-day F2F meeting, Stockholm CLC, July 2012
- Trends in Mediating Presence, Stockholm CLC, September 2012; co-arrangement with Charlie Gullström (KTH), ICT-Mediated Human Activity
- Trends in Digital Cities, Berlin CLC, October 2012; co-arrangement with Kåre Synnes (LTU), TDCT IR
- Trends in Networking Solutions for Future Media, Berlin CLC, October 2012; co-arrangement with Kåre Synnes (LTU), TFMC IR

The following foresight reports have been submitted in 2012 and are under current editorial and peer review. They will be published continuously as the editorial process proceeds, in accordance with the dissemination plan and synchronised with MarCom:

- Foresight Study "Smart Energy Systems"
- Six purported Foresight Technical Reports and one Foresight White Paper on "Digital Cities of the Future"
- Six purported Foresight Technical Reports and one Foresight White Paper on "Networking Solutions for Future Media"



Figure 1: Focus areas of ICT developments and trends observed in 2012

In addition, a number of documents on the business process and internal methods and results have been submitted to the intranet. Some of these are also on the radar tool (<http://www.innovation-radar.eu>).

3. Developments and Trends in ICT in 2012

The network of scouts and exports reporting to the EIT Innovation Radar in 2012 has shown a great deal of agreement regarding identified topics driving ICT industry. Many developments focus on the optimisation of existing infrastructure, especially using wireless standards as well as optical networks. Most developments have a mobile aspect, be it the network, devices, or applications. The "Cloud" remains a relevant buzz word, seeing much progress in crucial aspects: performance, security, and usability. Security remains a cross-functional topic not only relevant in the cloud, but across infrastructure, devices, and all areas of life.

The following pages describe observations concerning ICT developments and trends from the perspective of the Thematic Action Lines.

3.1 COMPUTING IN THE CLOUD

Cloud-related developments observed in 2012 mostly address security issues, but also efficiency of infrastructure and processes, and storage. Improvements have been made concerning the (energy-) efficiency of data centers (e.g., regarding cooling or speed of data transfer), and cloud services as such.

New types of databases are emerging, in order to meet new demand coming with the paradigm of Big Data. Especially NoSQL databases are gaining wider adoption with big players such as Amazon and Google offering their own flavours.



Figure 2: Focus areas of developments concerning Cloud IT in 2012

Distributed computing is seeing new solutions allowing breaking down computing tasks into convenient pieces. New algorithms increase the efficiency of analysing and processing huge amounts of data.

New storage technologies are optimised towards the handling of big data files and increased speed of searching data. Alternative designs of storage further address privacy and security, reducing the risk of unauthorised access. The evolution of memory technology enhances cloud infrastructure further, reducing latency.

Emerging cloud services mainly buzz in the areas of digital payment, cloud security, development frameworks (Backend-as-a-Service), and all kinds of XaaS.

Example Innovation: RAMCloud

A new class of general storage where all information (data) is stored in the main (DRAM) memories of hundreds or thousands of commodity servers; replaces magnetic disk and eliminate costly complex special fixes currently in use to lower latency in large scale Web apps such as large scale caching, minimal disk utilisation and trimmed back data structures.

With data resident in DRAM, latency is lowered a significant amount (100x to 1000x) and throughput is greater (100x to 1000x). Simplifies development/operation of large scale Web sites, cloud infrastructures.

Example Innovation: Strongly Isolated Computing Environment

A research prototype that uses existing hardware and firmware functionality to create a strong isolated environment to preserve the security of workloads running on cloud platforms. Based on fast switching between an isolated environment which it creates, and the hypervisor, SICE increases security with only a minimal hit on performance.

A research prototype that uses existing hardware and firmware functionality to create a strong isolated environment to preserve the security of workloads running on cloud platforms. Based on fast switching between an isolated environment which it creates, and the hypervisor, SICE increases security with only a minimal hit on performance.

3.2 DIGITAL CITIES OF THE FUTURE

Relevant developments observed in 2012 mainly include approaches to location and navigation, ICT-enabled access to services (with mobile devices as a key enabler in most scenarios), and display of information. All kinds of wireless technologies are being used for enhanced communication and interaction in urban environments.

One development increasingly being tackled with different approaches is indoor navigation, bringing location based services to places not covered by GPS. Further, many developments concern the optimisation of wireless transport of data in areas, where existing networks experience congestion due to the high density of mobile devices.



Figure 3: Focus areas of developments concerning Digital Cities in 2012

Example Innovation: WLAN Mesh Emergency Communication

Wireless Mesh Networks are very reliable communication networks and therefore suit to be used in emergency situations by first responders to coordinate efforts. First responders would greatly benefit from WMNs because of their rapid deployability and self-configuration capability.

Wireless Mesh Networks are not relying on terrestrial communication infrastructure and can still be upheld, if single nodes are destroyed.

Example Innovation: Wi-Fi Passpoint

An amalgamation of standards providing an emerging set of tools with a goal of providing ubiquitous public Wi-Fi service that is as 'automatic, transparent, consistent and secure as cellular service.' Enables devices to automatically identify, authenticate and join public Wi-Fi hot spots without the customary login processes; also initiates industry standard WPA2 security.

Enables differentiated services: managed, trusted, secure public hot spots, seamless roaming; extend service provider networks, maximise use of Wi-Fi for data services and improve end user experience.

3.3 NETWORKING SOLUTIONS FOR FUTURE MEDIA

Media is heavily ICT-driven and seeing many developments, which also drive the demand for suitable infrastructure. Developments observed in 2012 include standards enabling high quality video, in-

cluding means of preserving bandwidth (e.g., using codecs), wireless standards, and display technologies.

Available media increases through the wider range of channels, but also growth in user-generated and crowd-sourced content. To cope with overload, new approaches to multimedia search emerge as well as services delivering personalisation, aggregation, and visualisation of content. Social gaming is spreading and so are gamification elements, e.g. in advertising. Mobile gaming is seeing much buzz, both in adaption among consumers as well as new means of mobile interaction.

Alternative display technologies evolve, including built-in micro projectors and 'smart glasses' (enabling augmented reality). Other technologies enable scenarios, where users can watch different content from different angles, experience haptic feedback, and in general an enhanced user experience. Mobile phones/devices have become widely used as first or second screen (e.g., as companion device) in media consumption. User interfaces for transfer of media and for remotely controlling entertainment systems are evolving.

3D video has been addressed less, recently. But video quality further increases, and so does the demand for content. New approaches to media streaming come along with the trend, not to necessarily own content anymore. This increases the need to optimise and enhance network solutions. Hence, many developments observed focus on the optimisation of distribution and the underlying infrastructure. New codecs ensure keeping pace with the increasing demand for high-quality video content delivered in high speed.

Example Innovation: HEVC/H.265 Standard

A new VCEG/MPEG standardisation initiative, High Efficiency Video Coding (HEVC)/H.265 is aimed at significantly better compression enabled by using brute force computing cycles to enable more complex encoding. Though less complex, the decoding scheme, for receiving devices, also will need more computing power, which can be handled by the increasing processor power found in newer devices.

Next gen MPEG encodes video at lower bit rates; 35%-40% or more efficient than H.264 offering more immersive video experiences to a broad range of devices without incremental bandwidth consumption.

3.4 HEALTH & WELLBEING

2012 has seen many developments concerning health, wellness, and fitness. Developments include user-interfaces suitable for users with all kinds of disabilities. Many developments in take place in the connected home environment, especially wireless technologies and assistive solutions, e.g. robotics and telecommunication solutions. Specific wireless technologies are being developed for health applications, which guarantee the security of sensitive data, but also safety and reliability of the wireless devices. Plenty consumer services emerge in the area of mobile health monitoring, often facilitating sensors in combination with apps and a data connection.



Figure 4: Focus areas of developments concerning Future Media Networks in 2012

Example Innovation: WebRTC

WebRTC is a free, open project that enables web browsers with Real-Time Communications (RTC) capabilities via simple JavaScript APIs. It includes the fundamental building blocks for high-quality communications on the web such as network, audio and video components used in voice and video chat applications. WebRTC abstracts signalling, allowing developers to choose from iLBC, iSAC, G.711 and G.722 codecs for audio and VP8 for video.

WebRTC offers application developers the ability to write rich, real-time multimedia applications on the web without needing plugins, downloads or installs across multiple web browsers and platforms.

Example Innovation: Medical Body Area Networks

A low-power network of wireless sensors worn on the body with a controller to dynamically determine transmission frequency and aggregate and forward data. FCC allocated 40 MHz of spectrum in the 2360-2400 MHz range (shared) to operate in high density areas with numerous wearers. Spectrum allocation brings standardisation resulting in lower cost device manufacturing.

Provides the foundation for the development of a flexible platform for the wireless networking of multiple body transmitters that monitor and aggregate multiple, vital body functions.



Figure 5: Focus areas of developments concerning Health & Wellbeing in 2012

Example Innovation: Transient Electronics

Transient Electronic are high performance electronic components, bio-compatible and bio-degradable, capable of dissolving in water or bio-fluids after a set period of time with an initial use as medical implant devices for diagnostic or therapeutic purposes. Future applications potential as short-term environmental sensors or sub-components of consumer electronics.

Bio-compatible silicon- and magnesium-based circuits are encapsulated in silk. Adjusting the structure of the silk determines the time it takes for the device to dissolve and re-absorb.

Further developments and trends – in technology, economy, society, and politics – are being presented in detail by the CDTM study Ambient Assisted Living (2012a). Among others these include a shift to home-centred care, increasing importance of means for social interaction, a broader application of sensors and actuators, location-based services, as well as a shift of services and solutions towards the cloud.

3.5 ICT-MEDIATED HUMAN ACTIVITY

While ICT's role is mostly the support of humans, this area has seen the highest amount of developments on a very broad range. One major field is that of analytics, which gives insights into the needs of users and allows for a better targeting of services and information. Approaches include analytics of social media, but also usage patterns of mobile devices, as well as physical attributes (brain waves, facial expressions, voice, etc.), in order to detect emotions. New approaches to indoor navigation allow for better orientation, but also for better targeting,

e.g. of customers in a shopping mall. Prediction of movement not only helps optimising the usage of communication networks, but also targeting with content. Context information such as location is also being facilitated for automated communication. Analytics require high-performing infrastructure, smart algorithms, but also an ecosystem that ensures usage of insights in targeted, personalised services. Technological progress is being made regarding the precision of algorithms for user analytics, the efficiency of processing huge amounts of data, as well as the storage of this data.

Another important area is the display of information and user interfaces for interaction and communication. Augmented reality is increasingly used to display information in all areas of life, e.g. entertainment or automotive. User interfaces evolve supporting the grasping of information that is relevant for the user. New technologies and design approaches address, e.g. visually or hearing impaired users, in order to enable them to communicate via ICT.

Communication behaviour has changed in a direction, which favours IP-based communication, both VoIP and messaging applications. In the market, many products and services appear in the areas of messaging apps, increasingly also with real-time translation capabilities.

Example Innovation: Multiparty Motion Conferencing

Physically augmented screen movement combined with image motion enhances viewers understanding of gaze direction and increase accuracy in identifying addressees. Multiple screens, projectors, actuators, and loudspeakers are placed to recreate the actual seating arrangement.



Figure 6: Trending areas of ICT developments related to ICT-mediated Human Activity

User-centred shortcomings of video conference systems are addressed in novel ways. The viewer experiences a more realistic feeling of the presence of the remote people.

Example Innovation: Unobtrusive Mobile Emotion Recognition

Unobtrusive Emotion Recognition predicts a user's mood state from passively collected data on mobile device usage. The categorisation between the states "happy", "surprised", "angry", "disgusted", "fearful" and "sad" reaches an accuracy of 67.5% after a few sessions with a single user machine-learning algorithm.

The innovation is the passive collection of user mood states just by collecting correlations between mood and cues like space bar or special character input frequency, typing speed or accelerometer and location data.

3.6 INTELLIGENT MOBILITY AND TRANSPORTATION SYSTEMS

Most of the developments and trends observed by the Innovation Radar have been in the area of automotive. Though applicable to other means of transportation as well, batteries have seen much development as a key enabler of e-mobility. Further,

the connectivity of vehicles (but also on board of trains or airplanes) has seen many developments as regards standardisation of wireless technologies, infotainment services, and safety.

Related to infotainment, new display technologies have been identified, enabling interaction with information or augmented reality approaches to the display of information. Beyond displays, user interfaces are being developed that avoid distraction, but also enable impaired users to conduct a vehicle, e.g. using brain waves or steering with their tongue.

Further progress has been made in the area of smart navigation as well as in autonomous vehicles.

Example Innovation: Secure Vehicle Updates

Fraunhofer developed a central trust anchor which stores single car device keys in a central location. To prove software update requests are coming from the vehicle system and have not been manipulated, it checks whether the device software matches the valid version. If validated, the system receives the key required to establish a secure VPN channel to the manufacturer and download the desired software.

With this new trust anchor and a centralised key storage, the handling of cryptographic car device keys could be simpler and more economical in the future.



Figure 7: Trending areas of ICT developments related to TIMS

Example Innovation: Shared automotive Internet connectivity

The aggregation of data from multiple cars to just a handful and then upload it to the Internet, is the general approach behind a new algorithm republished in July 2012 by MIT, Georgetown University and the National University of Singapore (NUS).

Because of the constant change in the layout of a network, where cars are taking unpredictable ways, data is being aggregated by the cars that come into contact with the largest number of other cars.

3.7 INTERNET TECHNOLOGIES AND ARCHITECTURE

Developments and trends regarding Internet Technologies and Architecture have been intense in terms of optimisation of existing infrastructure in both, performance (e.g., via more efficient routing) and energy-efficiency (e.g., utilising laser and LED technology for high-speed, energy-efficient data transfer). Infrastructure solutions for high speed data transmission are being implemented, including optical approaches and Tera wave technology. Energy efficient data centers and storage further support the optimisation of infrastructure. Additional progress is being made in the area of congestion management and load balancing, increasing the overall performance of existing infrastructure. Software Defined Networking and OpenFlow are promising technologies facilitated in these regards.

As Internet access is more and more performed via mobile devices, much has been done concerning optimisation and standardisation of wireless technologies and infrastructure (e.g., by increasingly facilitating and improving Wi-Fi, enhancing interoperability of wireless standards, increasing data rates, or reducing interferences in the unlicensed wireless

spectrum). Mobile data access is spreading further to areas such as the home, automobile, trains, and airplanes. Antenna technologies are being developed, which allow for further optimisation and network coverage. Mobile broadband has seen several breakthroughs in wireless transmission speed, both long- and short-range. Further developments concern the optimisation of routing as well as the optimisation of the wireless spectrum – through wireless standards as well as by analysing user behaviour and predicting future traffic. Also the measurement and visualisation of (not only wireless) network traffic is an important means of optimisation, e.g. of the wireless spectrum, also in home environments. Additional efforts are currently being made regarding improved wireless access for Car-to-x. Improvements have been made concerning self-management capabilities of wireless infrastructures. Increasingly developments can be observed in the area of software defined networking (SDN). Consumer market offerings focus on sharing wireless access and services for billing and monitoring data and battery usage of mobile devices.

Optimisation has also been progressing on the level of data centers in terms of speed, computing capabilities, and energy consumption (e.g., through optimised processors or approaches to cooling).

Example Innovation: TCP Fast Open Protocol

TCP Fast Open Protocol (TFO) substantially decreases transaction network latency and speeds up the load time of a Web page. With new security mechanisms to guard against denial-of-service attacks; TFO can be incrementally deployed; draft submitted to IETF standardisation; part of Google's "Let's Make the Web Faster" initiative.



Figure 8: Trending areas of ICT developments related to Internet Technologies & Architecture

A revision to the TCP architecture that eliminates the many extra TCP RTTs that is characteristic of today's web services; improves user experience, conserves networking and server resources.

Example Innovation: Controlled Delay Management

A generalisable, efficient, parameter-less approach to Active Queue Management that can be applied to single or multiple queues to be used as a tool to help solve "buffer bloat" to relieve congestion and improve performance at the consumer-facing network edge, particularly for time sensitive or streaming media apps.

Based on time - uses the actual delay experienced by each packet in buffer; as self-contained algorithm, does not require operator intervention for configuration; adaptable to multiple queue systems.

3.8 SMART ENERGY SYSTEMS

While nearly every development in ICT has also aspects of energy – mostly energy-efficiency – we have not observed many new topics specifically in the area of energy systems. A vast amount of developments could be seen in battery technology, which however is not exclusive to smart energy systems. With the rise of e-mobility and the scarcity of certain materials required in batteries, there is an on-going need to improve capacity, lifetime, environmental friendliness, weight, size, charging time, etc. not only for automotive applications and mo-

bile devices, but also for a smart energy grid that has to constantly cache electric energy from unsteady sources.

While there are many such (renewable) sources, most developments observed in 2012 have been in solar (photovoltaic) energy, creating new form factors and increasing efficiency drastically, while enabling new applications.

Example Innovation: Nano-antenna Photovoltaics

State-of-the-art solar panels are largely silicon-based and suffer from modest efficiency coefficients. By relying on nano-antennas instead of semiconductors, scientists have developed a solar panel that promises to be more efficient by several magnitudes. The first prototype features a plastic panel with small metallic antennae imprinted (consisting of small quantities of aluminium and gold), which pick up a broad spectrum of light that current semiconductors cannot deal with.

First proof-of-concept tests yielded values regarding light absorption and energy generation capacity, indicating an energy efficiency of approximately 95%. Compared to current solar efficiency coefficients (approximately 7%), this would imply a dramatic improvement.

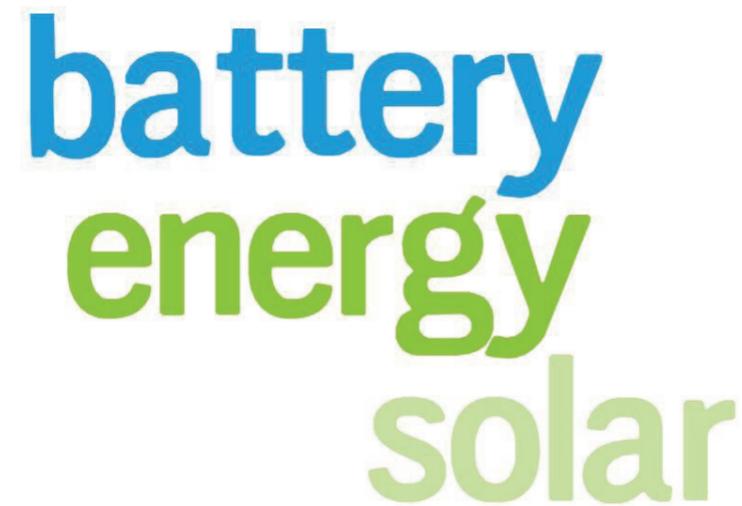


Figure 9: Trending areas of ICT developments related to Smart Energy Systems

Example Innovation: Liquid Battery

Hot liquid metal compounds have been discovered to be an efficient and cost-effective way of storing energy. The batteries are designed as an alternative to wind energy stores that collect surplus energy during peak times and supply it back into the electricity grid during low peak times. In the charging process, a powder is heated up until it turns into a liquid that consists of three layers, serving as electrodes and electrolyte.

This design has several advantages like high conductivity, fast re- and discharging (within a few milliseconds) and high density (up to 200 mA per cm²). The source material is mainly magnesium (which is highly affordable and available in large quantities in natural resources).

Further developments and trends considered to having a high impact on Smart Energy Systems have been identified through the Innovation Radar Foresight Study on Smart Energy Systems (2012b). The paradigm of Big Data and analytics of such data enable new business also in the energy sector, e.g. in the context of smart metering. Remote (cloud-based) energy management in the context of the connected home has been considered as highly relevant as well for efficient management of appliances, heating, etc. Finally, the field of wireless power with applications from charging mobile devices to electric vehicles – on the road or as integral component of the smart home – has been identified as promising regarding enabling of new products, services, and applications.

3.9 SMART SPACES

Most developments observed in 2012 concern display technologies for display of and interaction with information (e.g. touch screens). Further technologies concern alternative user interfaces for interac-

tion (e.g., gesture or gaze-based interaction, as well as brain-interfaces). Finally, plenty of wireless technologies are being developed for exchange of data. This also includes sensor for collection of contextual information.

New approaches to indoor navigation allow for better orientation, but also for better targeting, e.g. of customers in a shopping mall. Technological progress is being made regarding the precision of algorithms for user analytics, the efficiency of processing huge amounts of data, as well as the storage of this data. Augmented reality solutions emerge in an increasing number of application areas. New services in the market offer recommendation based on user behaviour – mainly for e-commerce and entertainment purposes, augmented reality in combination with location and advertisement, location-based social applications for sharing of objects, as well as contextual information and visualisation for productivity and business.

Example Innovation: LiFi

An emerging subset of visible light communication (VLC) for wireless, optical, high speed, short range data exchange via light waves useful in environments where RF communications is restricted. Has the potential for multi-gigabit, short range optical interconnects, used as an alternative to WiGig, or an alternative to the emerging Giga-IR spec to replace USB 3.0 and HDMI cable connectors, or as a component of novel, hybrid communication apps.

Piggybacks onto the LED lighting infrastructure and enabled by a new generation of high brightness LEDs and novel transmitter or transceiver silicon designs incorporated into the LED bulbs.

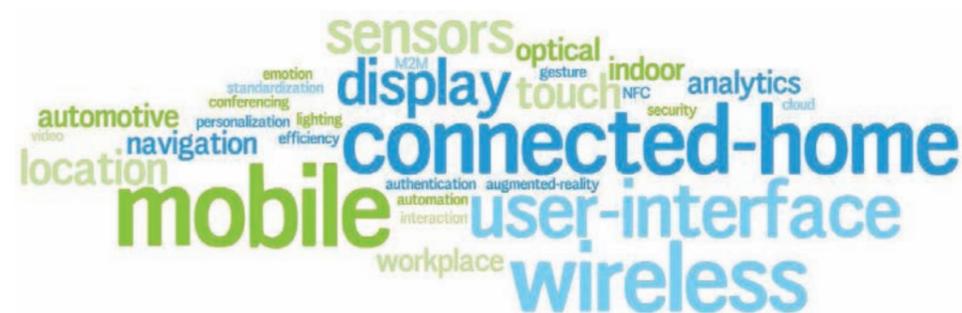


Figure 10: Trending areas of ICT developments related to Smart Spaces

Example Innovation: LiFi

An emerging subset of visible light communication (VLC) for wireless, optical, high speed, short range data exchange via light waves useful in environments where RF communications is restricted. Has the potential for multi-gigabit, short range optical interconnects, used as an alternative to WiGig, or an alternative to the emerging Giga-IR spec to replace USB 3.0 and HDMI cable connectors, or as a component of novel, hybrid communication apps.

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3.10 PRIVACY, SECURITY & TRUST IN INFORMATION SOCIETY

Privacy and security are overarching topics, relevant in all areas of ICT. The developments observed in 2012 concern privacy and security in web browsers, email communication (e.g., protection from spam), connected cars, the connected home, the cloud and its applications, smartphones, as well as the infrastructure as such.

Security of data, networks and devices is being tackled by a plethora of new solutions. Many developments could be observed facilitating biometrics for security. Voice identification is being applied to multiple areas, including automotive environments. Mobile security solutions are emerging, focusing on protection from malicious attacks on devices and networks, but also on secure device interaction, e.g. facilitating biometrics. Securing communication is mainly achieved by means of encryption.



Figure 11: Trending areas of ICT developments related to Privacy, Security & Trust

Example Innovation: Route Origin Verification

Border Gateway Protocol (BGP), the Internet's core inter-domain routing protocol, is its weakest link of the Internet's routing infrastructure. Route Origin Verification or ROVER aids the BGP protocol and allows receiving router to verify that the IP address blocks announced by other routers do indeed belong to their network.

Leverages DNSSEC to protect BGP using reverse DNS entries in CIDR, ROVER needs no changes to be made to existing routers, and it can work alongside of and complement RPKI.

4. Methodology

4.1 IDENTIFICATION

Developments and trends have been identified by the international scouting network of Deutsche Telekom Innovation Laboratories as well as by various partner organisations of EIT ICT Labs in the course of creating Foresight Studies and Technical Reports for the Innovation Radar.

4.2 SELECTION & ASSESSMENT

Out of a long-list of topics 259 topics have been selected for further assessment. This short-list can be found in the appendix of this document.

Double postings have been filtered or merged. Based on the assessment of 40+ experts, topics with a lack of novelty and/or relevance have been sorted out.

In a first step, all topics have been evaluated in terms of relevant topic clusters. The number of topics per cluster has been assessed for the identification of major areas of ICT-related developments. In a second step all topics have been matched with the Thematic Action Lines of EIT ICT Labs, in order to identify hot spots not only from an overall ICT perspective, but also from the perspective of each thematic area. Therefore, also the number of topics per cluster within each Thematic Action Line has been assessed.

4.3 EVALUATION

The resulting clusters – visualised as tag clouds – have been used for further evaluation of the clusters themselves from both, an ICT perspective as well as a Thematic Action Line perspective. Developments within clusters have been summarised, indicating promising areas of on-going and future developments. Overarching topics have been pointed out, which have relevance for more than one Thematic Action Line, thus should receive more attention. Other Innovation Radar insights (from Foresight Studies and Technical Reports) complement the view on the observed developments and trends.

5. References

CDTM (2012a). *Ambient Assisted Living*, Trend Report 2011/2012.

EIT ICT Labs (2012b). *Innovation Radar Foresight Study: Smart Energy Systems*, EIT Innovation Radar.

Appendix: Topics



ID	Topic Title	Thematic Action Lines										Keywords	
		Computing in the Cloud	Cyber-Physical Systems	Digital cities of the Future	Networking Solutions for Future Media	Health & Wellbeing	ICT-mediated Human Activity	Intelligent Mobility and Transportation Systems	Internet Technologies and Architecture	Smart Energy Systems	Smart Spaces		Privacy, Security & Trust in Information Society
IR-001	Strongly Isolated Computing Environment (SICE)	x									x		cloud, security, performance
IR-002	TapSense					x				x			interaction, user-interface, touch
IR-003	Do Not Track Standard (DNT Standard)										x		privacy, browser, standardisation
IR-004	Enhanced collective intelligence					x				x			analytics, recommendation
IR-005	Nanoscale Single-mode LED						x						optical, photonics
IR-006	SideBySide					x							collaboration, display
IR-007	OmniTouch					x							user-interface, touch
IR-008	Open Source Routing Project (OSR)						x						open-source, routing
IR-009	RAMCloud	x											storage, cloud, performance
IR-010	Airshark								x				wireless, efficiency
IR-011	Low-energy servers with cell phone chips	x											computing
IR-012	Nano-antenna photovoltaics							x					solar
IR-013	ExoGENI	x											testbed, cloud
IR-014	SpamFlow								x				spam, security
IR-015	Sovereign Key Specification (SK)									x			security
IR-016	Signcryption									x			security, encryption
IR-017	3D Cell Phone Camera					x							mobile, 3D
IR-018	Optical fiber microresonators						x						storage, photonics
IR-019	Low-power UV lasers						x						photonics
IR-020	Secure updates for vehicle devices					x				x			security, automotive, update
IR-021	Manganese-Gallium magnets										x		rare-earth
IR-022	Improved optic microfabrication										x		photolithography
IR-023	Simple 2-factor authentication										x		authentication
IR-024	Multimedia Resource Allocation			x									shadow-pricing
IR-025	Store a bit in 12 atoms										x		storage
IR-026	Cloud Shredder	x									x		cloud, security
IR-027	Bluetooth 4.0/BLE									x			wireless, sensors
IR-028	TCP Fast Open protocol/TFO						x						TCP
IR-029	DMARC										x		security, phishing
IR-030	LiFi					x				x			wireless, optical
IR-031	Intel Cilk Plus: Facilitating Parallel Programming											x	mobile, multi-core
IR-032	Super Hi-Vision: 8k x 4k Resolution					x							display
IR-033	Body Scanners: Checkpoint of the Future			x									security
IR-034	Cloud Security and Data Independence	x									x		storage, cloud, security, encryption
IR-035	Fast Fourier Transformation on Speed						x						optimisation
IR-036	Simple Emotion Recognition			x		x				x			analytics, mobile, emotion
IR-037	Bandwidth Boost via Network API						x						bandwidth
IR-038	Mini Redox Flow Batteries						x						battery
IR-039	Content Revenue Alliance											x	publishing, commercialisation
IR-040	Fusion Memory Chips											x	memory
IR-041	DataPROVE	x									x		cloud, security
IR-042	Self-healing Batteries						x						battery
IR-043	TDR Touch Sensor Project					x				x			touch, sensors

ID	Topic Title	Thematic Action Lines										Keywords	
		Computing in the Cloud	Cyber-Physical Systems	Digital cities of the Future	Networking Solutions for Future Media	Health & Wellbeing	ICT-mediated Human Activity	Intelligent Mobility and Transportation Systems	Internet Technologies and Architecture	Smart Energy Systems	Smart Spaces		Privacy, Security & Trust in Information Society
IR-044	Ford SYNC Leverages Car Healthcare Services					x		x					health, wellness, automotive, wireless
IR-045	Light-emitting electrochemical transistors						x	x					display
IR-046	HOSPI-Rimo: Panasonic's Care Assistance Robot					x							health, robotics
IR-047	SMILE plug – a cloud for the classroom	x		x									education, cloud
IR-048	Country Withheld Content			x									content, censorship
IR-049	TV Genome						x						analytics, social, recommendation
IR-050	Twine Sensors	x	x		x		x				x		sensors, cloud
IR-051	Micro-Microphone											x	miniaturisation
IR-052	Education-Specific-HTML											x	education, standardisation
IR-053	IPv6 Privacy											x	privacy, IPv6
IR-054	Capacitive body coupling						x				x		wireless
IR-055	Vibration API						x						haptic, user-interface
IR-056	WiFi Passpoint			x						x			wireless, authentication
IR-057	Smart Glass – Using Windows As Interactive Screens						x	x					user-interface, display
IR-058	Virtual Sky										x		lighting, connected-home
IR-059	Hybrid personal storage	x										x	storage, security, cloud
IR-060	New Error Correction Encoding Scheme							x					bandwidth, efficiency
IR-061	ZZFS	x										x	cloud, security, remote
IR-062	Pocket Touch						x						user-interface, touch
IR-063	ACE Hearing: Adjusting Sound Output					x	x						mobile, voice, hearing, health
IR-064	Database-as-a-Service: Access-Restricted Cloud Computing	x										x	cloud, security
IR-065	Smartphone-based Biometrics						x					x	mobile, security, biometrics
IR-066	Bouncing Data Speeds Up Internet	x											data-center, optimisation
IR-067	Wi-Fi Narrow Channel										x		wireless, optimisation
IR-068	Content Prediction						x						recommendation, analytics
IR-069	Anti-Distracted App for Drivers										x		safety
IR-070	Ultra-Fast Magnetic Data Storage	x											storage, cloud
IR-071	Haptic Touch Interfaces						x						user-interface, haptic, touch, display
IR-072	Touchscreen Braille Input						x						display, impaired
IR-073	Radio Signal Visualisation										x		visualisation, optimisation, wireless
IR-074	Smartphone Train Information System / Repurposing Information						x	x					travel
IR-075	Mobile Neuro-Wear						x						gaming, user-interface, brain
IR-076	Capacitive Touch Sensors (Skin)						x	x					sensors, user-interface, health
IR-077	Security Honey pots by Design											x	security, honeypot
IR-078	Google KeyChain API						x					x	mobile, enterprise, security, BYOD
IR-079	Universal Remote Control						x						remote, mobile, entertainment
IR-080	Network Outage: Limiting Android Data Use											x	bandwidth
IR-081	New Ways of Working											x	workplace
IR-082	RAN sharing										x		wireless, optimisation

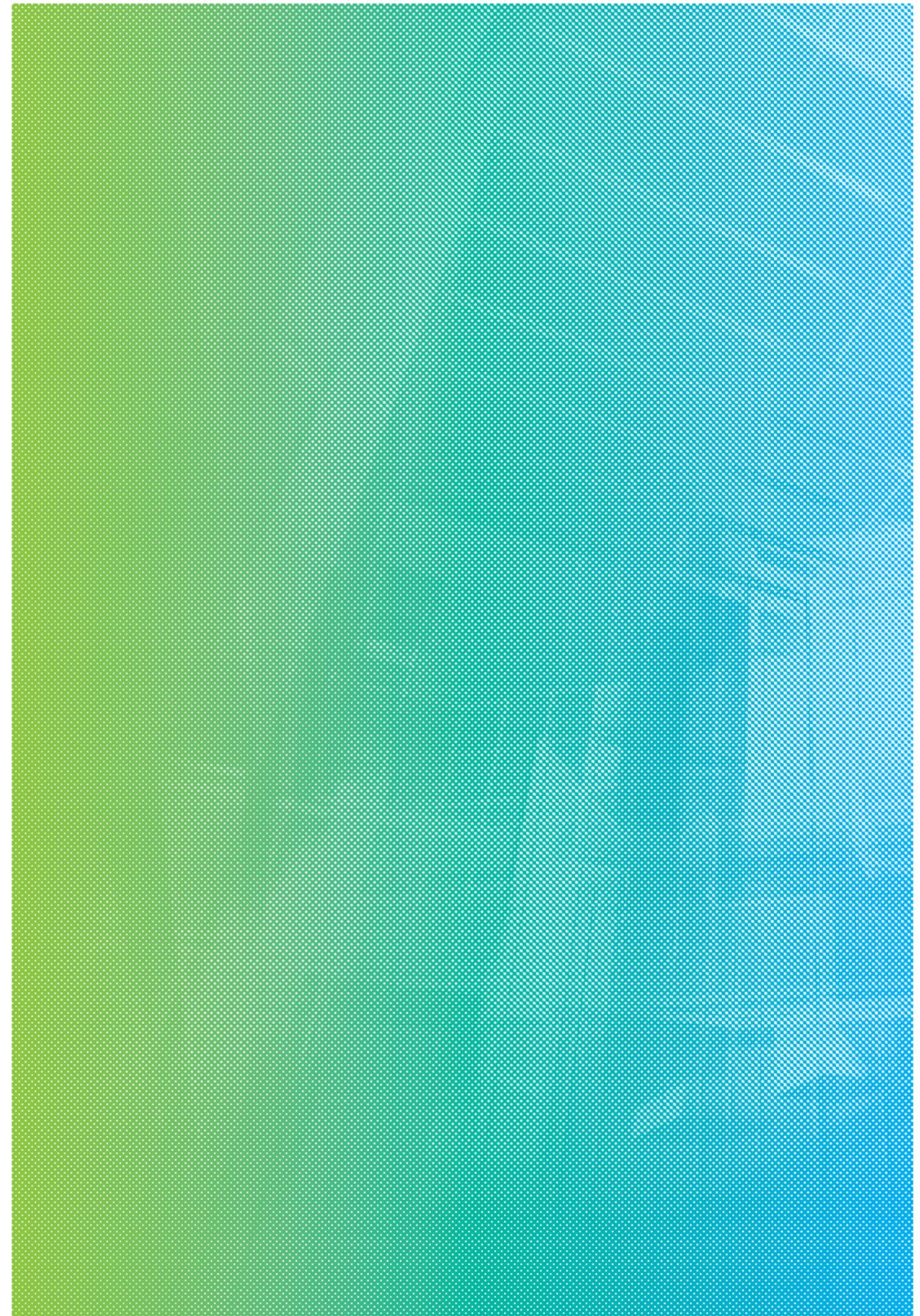
ID	Topic Title	Thematic Action Lines										Keywords	
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IR-083	Cloud RAN	x						x					cloud, wireless
IR-084	Multi-point HSDPA (HSPA+ Multiflow)							x					wireless, optimisation
IR-085	Mobile relaying							x					wireless
IR-086	Home network topology discovery								x				standardisation, connected-home
IR-087	Real-Time Probing of Available Bandwidth in Home Networks					x							diagnostics, connected-home
IR-088	LTE Infotainment			x			x	x					wireless, automotive, entertainment
IR-089	Body Heat Electricity					x							electricity
IR-090	Prescribed Apps				x	x							health, mobile, monitoring
IR-091	Heat-based recording											x	storage
IR-092	Liquid Submerged Server	x											data-center, cooling
IR-093	Liquid Net							x					self-optimisation
IR-094	ECMAScript: Pushing JavaScript Runtime											x	development
IR-095	Brain-Tongue-Computer Interface					x							user-interface, impaired, brain
IR-096	Distributed Computing with Finite State Machines	x											cloud
IR-097	Dual View					x							display
IR-098	ByteLight			x		x				x			mobile, navigation, indoor
IR-099	BitTorrent Live			x									video, streaming
IR-100	Personal Data Analysis					x							analytics
IR-101	Taste Graphs					x							analytics, recommendation
IR-102	Physical Remote Collaboration								x				workplace
IR-103	3D Interactive Display Technology					x				x			user-interface, 3D, display
IR-104	Holoflector					x							user-interface, display
IR-105	Tonguedrive					x	x			x			user-interface, automotive
IR-106	HSPA+ Multiflow							x					wireless
IR-107	Car Connectivity						x						connectivity, mobile, automotive
IR-108	Socialbots					x							social, analytics, recommendation
IR-109	Caringo Object Storage Platform 5.5: Chunked Encoding for Cloud-Based Replica Backups	x											cloud, storage
IR-110	Virtual Patient				x								health, personalisation
IR-111	LTE direct mode							x					wireless
IR-112	Low-Cost Satellite Revolution							x					satellite
IR-113	1,4 Tbit/s wireless data transmission							x					laser, optical
IR-114	Optoelectronic Data Transmission Device							x					optical, photonics
IR-115	Opus Audio Codec				x								audio, codec
IR-116	Consumer NFC Stickers			x		x				x			NFC, mobile
IR-117	Amazon launches DynamoDB	x											cloud, database
IR-118	Gogo WiFi advancing forward							x					wireless, travel
IR-119	OpenACC: New Parallel Programming Standard												development
IR-120	Degate Smartcard Check											x	security, encryption
IR-121	Automated Wi-fi Roaming							x					wireless, mobile, handover
IR-122	Huawei presents Beyond LTE							x					mobile, wireless
IR-123	Standard x-arf											x	messaging, security

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IR-124	Maximising Frequency Capacity through Radio Vorticity										x		wireless, optimisation	
IR-125	Apps for Convergence of TV and Touchscreen Devices								x				entertainment, social, companion	
IR-126	Future XML Encryption											x	security, encryption	
IR-127	Media Encryption & Rights Management for HTML5											x	security, encryption, media	
IR-128	WiBack									x			wireless, backhaul	
IR-129	Personal Mobile Risk Management											x	mobile, enterprise, security, BYOD	
IR-130	Electronic multi-touch floor covering										x		security, connected-home	
IR-131	Temporal Psychovisual Modulation												display	
IR-132	Tails: Anonym OS											x	privacy, anonymity, OS	
IR-133	More privacy through crowdsourcing											x	privacy, crowdsourcing	
IR-134	Collaborative Consumption	x											sharing	
IR-135	SARTRE: Road train									x			transportation, automotive, autonomous	
IR-136	Big data management extension	x											Big-Data, database	
IR-137	Ant communication										x		routing, optimisation	
IR-138	Vein authentication											x	authentication, biometrics	
IR-139	Crab Computing												energy-efficiency	
IR-140	UDID Replacement	x										x	privacy, mobile	
IR-141	html.next alias HTML6												x	development, standardisation
IR-142	Smart Replication: Accelerate Big Data Handling	x											Big-Data, analytics, database	
IR-143	Kyocera Smart Sonic Receiver Technology												x	audio, mobile
IR-144	Higher Ethernet Efficiency With New 802.1aq Standard										x		wireless, optimisation	
IR-145	Neutrinos Message Transmission										x		transmission, neutrinos	
IR-146	Broadband and Broadcast Convergence						x						wireless, convergence, video, broadcast	
IR-147	Several Antennas in One												x	mobile
IR-148	Intelligent Media Libraries												x	search
IR-149	Liquid Battery										x		energy, battery	
IR-150	Contextual Intelligence for Telco											x	analytics, targeting, advertising	
IR-151	Teleportation										x		teleportation, security	
IR-152	Flat Datacenter Storage (FDS)	x											data-center, storage	
IR-153	Low Energy Radio Stack						x						wireless, energy-efficiency	
IR-154	Electric Imp											x	connected-home	
IR-155	Prevention of side-channel attacks											x	security, mobile	
IR-156	Microsoft HomeOS											x	connected-home	
IR-157	Spray On Antenna												x	connectivity, mobile
IR-158	BigQuery	x											Big-Data, analytics, database	
IR-159	HEVC/H.265 Standard							x					video, codec	
IR-160	Holey Optochip	x											cloud, computing, optical	
IR-161	IEEE 802.3 Reduced Twisted Pair Gigabit Ethernet											x	automotive, wireless, energy-efficiency	
IR-162	Virtual Projector											x	display, mobile	

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IR-163	OLED Energy Harvesting												×	display, mobile, energy-efficiency
IR-164	Route Origin Verification (Rover)												×	security, routing
IR-165	Packet-switched On-chip Network												×	routing
IR-166	O-RAM							×						optical, memory, storage, routing
IR-167	Fused Processor Architecture												×	computing
IR-168	Plastic Electronic Paper Display (EPD)												×	display
IR-169	Pindrop												×	voice, location, security
IR-170	TeraHertz Band Wireless Communication												×	wireless, mobile
IR-171	Heads-up Laser Display						×			×				mobile, automotive, display, augmented-reality
IR-172	10 GHz Silicon Optical Transistor												×	optical
IR-173	Ubuntu for Android						×							mobile, enterprise, productivity, OS
IR-174	Touché						×			×				user-interface, touch, display
IR-175	YourView: User Creditability Rating						×							social, media, crowdsourcing, opinion
IR-176	Dragon ID Voice Identification												×	voice, security, identification, biometrics
IR-177	TeraStream	×						×						cloud
IR-178	Lib-Ray: Open HD-Video												×	video, open-source, codec, standardisation
IR-179	airFiber: Hybrid Division Duplex								×					mobile, wireless, backhaul
IR-180	DC Data Center	×												data-center, energy-efficiency
IR-181	3 Gbps Short-Range Wireless with T-Rays												×	wireless
IR-182	Enhanced Secure ID												×	mobile, enterprise, security, BYOD
IR-183	Portable HD TV												×	video, wireless
IR-184	MANET data transmission									×				optimisation, routing
IR-185	Modular In-Car Interfaces						×	×						automotive, user-interface
IR-186	Next Generation Touchscreen Keyboard						×			×				user-interface, gesture
IR-187	Brainput						×							user-interface, brain
IR-188	Pirate Pay (Pirate Blocking)				×									P2P, DRM
IR-189	on[x]						×			×				automation
IR-190	Smartphone Hijacking												×	mobile, security
IR-191	Colloidal Display						×							display, 3D
IR-192	Sharing data links in networks of cars							×						wireless, automotive
IR-193	Smart TV Alliance												×	standardisation, video, open-source
IR-194	FM-based Indoor Localisation			×						×				location, mobile, indoor
IR-195	MBANs					×	×							sensors, health
IR-196	ZUIs			×										user-interface
IR-197	Flexible Channel Width Wireless Network									×				wireless, optimisation
IR-198	Trust Assertions for Certificate Keys (TACK)												×	security, certificate
IR-199	Twisted RF Communication									×				wireless, optical
IR-200	CoDel (Controlled Delay Management)									×				congestion, buffer, optimisation
IR-201	WS-BD Protocol												×	security, biometrics, wireless

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IR-202	SoundWave												×	user-interface, gesture	
IR-203	Hybrid Memory Cube	×												×	memory
IR-204	Open Flow Silicon											×		virtualisation, SDN, wireless, open-source, data-center	
IR-205	Flexible Color E-Paper Screen												×	display	
IR-206	Acoustic Display: Motorola Files Free Form Lens Patent												×	display	
IR-207	Open eCard App												×	identification, security, open-source	
IR-208	Prevention of Cell Phone Accidents										×			safety, automotive, mobile	
IR-209	Mobility Pattern Prediction Algorithms											×		analytics, location, personalisation	
IR-210	Energy efficiency of cloud solutions	×												cloud, energy-efficiency	
IR-211	Bitcoin												×	payment	
IR-212	Self-management for heterogeneous mobile networks											×		mobile, self-optimisation	
IR-213	Writing by Eye Movement												×	user-interface, gaze	
IR-214	Mobile Remote-Login with MOSH	×											×	mobile, remote, security, cloud	
IR-215	WebAudio API													×	browser, audio, standardisation, API
IR-216	Red Phone												×	security, encryption, mobile, communication	
IR-217	WebDriver API													×	testing, API
IR-218	Web Performance Measurement													×	browser, standardisation, optimisation
IR-219	Sparse Interference Algorithm												×	security	
IR-220	HALide													×	development
IR-221	Energy-efficient transport from magnetic bits based on energy-efficient storage	×													storage, energy-efficiency
IR-222	Social fMRI												×	analytics, social	
IR-223	Open Mobile Network Modeling												×	mobile, optimisation	
IR-224	OpenRadio												×	wireless, virtualisation	
IR-225	Serval												×	dynamic, architecture, load-balancing	
IR-226	60 GHz LAN												×	wireless, base-station	
IR-227	Transient Electronics												×	medical, biodegradable, sensors	
IR-228	Firefox OS for Smartphones													×	mobile, OS, browser
IR-229	Spanner	×													database
IR-230	Wi-Fi Inside													×	wireless
IR-231	Miracast												×	video, streaming	
IR-232	WebRTC 1.0/ CU-RTC Web												×	standardisation, browser, communication	
IR-233	Argos												×	wireless, base-station, optimisation	
IR-234	Persona	×											×	security, open-source, certificate	
IR-235	Amulet												×	identification, authentication, sensors, biometrics	

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IR-236	Pleiades										×		security, botnet
IR-237	Ultra-Thin Lens											×	lens, photo
IR-238	Grip UI						×	×					user-interface, mobile
IR-239	MM-Space: Intuitive Video Conferencing						×				×		video, conferencing
IR-240	Short-range Visible Light Communication			×							×		wireless, optical, mobile, location
IR-241	Leap: 3D Motion Capture Interface						×						user-interface, gesture
IR-242	Dynamic Policy-Based Smart Device Management										×		mobile, security, enterprise, BYOD
IR-243	HTTP 2.0							×					optimisation, standardisation, bandwidth
IR-244	MegaDroid										×		security, mobile
IR-245	Optical Relay							×					optical, energy-efficiency, optimisation
IR-246	Silent Circle										×		mobile, security, encryption, communication
IR-247	Coded TCP							×					congestion, wireless, optimisation
IR-248	Converge						×						automotive, transportation, traffic, connectivity
IR-249	W3C Web Cryptography API										×		security, encryption, API, standardisation, browser
IR-250	SpiderFab: low-cost kilometer-scale antennas in space							×					satellite
IR-251	Internet of Things Kits									×			connected-home, M2M
IR-252	WLAN Mesh for Emergency Communications			×				×					wireless, emergency
IR-253	Secure Non-browser-based SSL Validation										×		security, e-commerce
IR-254	Super Persistent Quartz Storage	×											storage
IR-255	The Pocket Radar: Thumbtack-Sized Distance and Motion Sensor			×			×			×			navigation, sensors
IR-256	Social Media Programming Language Dog											×	social, development
IR-257	Making Web applications more efficient: Automatic Partitioning of Database Applications	×											database, optimisation
IR-258	Connectify Dispatch							×					wireless
IR-259	Video Aware Wireless Networks (VAWN)			×			×						wireless, video, optimisation



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