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MESSAGE FROM COMMSOFT TC CHAIR

The Technical Committee on Communications Software (TC-COMMSOFT) examines methods and techniques devoted to advancement of the formal methods and tools, use of system analysis and design, methodology for development of communications protocols as well as application of general Software Engineering approaches for the purpose of development of communications applications. The issues addressed by the TC-COMMSOFT include domain-specific languages and practices of using them. Developing of "middleware" between networks and applications and the usefulness and usability of it is also a topic.
In this volume, we have selected 3 papers on three various subjects: wireless sensor networks for smart cities, routing protocols for mobile AdHoc networks and cloud computing.

Wireless Sensor Networks for Intelligent Transportation Systems

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Abstract: In this article, the possibilities of wireless sensor networks (WSN) integration into the field of intelligent transportation systems (ITS) will be introduced. An overview of typical application scenarios followed by one exemplary case study will provide anticipated view on the direction of future ITS approach.

Keywords: WSN, ITS, car detection, magnetometer

1. Introduction

A few years ago, the applications of WSN were rather interesting example than a powerful technology. Today it is expected that in next decade WSN world market grows approximately five times from the value of 0.45 billion USD in 2011 to 5 billion USD in 2021 [1]. According to the report SE 1662 made by Markets and Markets [2] The Industrial Wireless Sensor Networks (IWSN) Market for Manufacturing & Process Control Automation is expected to grow from USD 1610.00 million in 2011 to USD 3795.37 million in 2017, at a CAGR (Compound Annual Growth Rate) of 15.58% from 2012 to 2017. In the report published by OnWorld [3], it is forecasted that within the next five years, 1 billion circuits will be shipped per year for WSN markets. The installed wireless industrial field devices will increase by 553% when there will be nearly 24 million wireless-enabled sensors and actuators, or sensing points, deployed worldwide [4]. By 2016, 39% of deployed nodes will be used for new applications that are uniquely enabled by WSN technology. These values of market increase do not consider non-mesh wireless sensors, which represent another large space for developers and manufacturers of WSN components and applications. Though, at the present time the vast majority of installed sensors communicate via wire line, it is expected that over the next 10 years, the WSN will represent more than 10% of the all sensor networks installed [1]. Regarding [5], as well as [6], it can be also mentioned that the use of WSN compared with traditional solutions has decreasing financial requirements for installation and maintenance. It is expected that the average price of a sensory element will drop from the present 9 USD to 5 USD by 2021.

A distributed networked sensor system or wireless sensor network consists of numerous coupled subsystems, which are geographically spread. In such system, individual subsystems are called clusters and these cluster exchange information over the communication network. In practice, communication, especially wireless communication, takes place over digital networks where the data is transmitted in discrete packets. These packets may be lost during communication. Moreover, the communication media is a resource that is usually accessed in a mutually exclusive manner by neighbourhood clusters / nodes. This means that the throughput capacity of such networks is limited. So, one important issue in such systems implementation is to identify methods that use the limited network bandwidth more effectively. In other words, timing issue is present. The timing issue gives the answer to the question how frequently should subsystems / nodes communicate to ensure that the cluster as well as the network itself has a desired level of performance. In traditional approaches, digital signal processing needs an essential condition to be deployed which according to the sampling theorem, the maximum frequency contained in a signal must be less than half of the sampling frequency. This condition cannot be achieved with some applications (like some types of the sensor networks). Event-driven sampling sometimes referred as a non-uniform sampling is the solution to this problem [7] [8]. Typical event-detection mechanisms are functions on the state or on the system output variation. The event-triggered control allows reducing the periodicity of the control unit computations. It is proved that such an approach reduces the number of sampling instants for the same final performance [9].

The typical WSN should be characterized by following attributes:

- low power consumption followed by utilization of energy harvesting, resulting to long lifetime;
- integration of effective and reliable IEEE compliant communication protocol (IEEE 802.15.4 or IEEE 802.15.6);
- network management possibilities, data collection, data processing;
- integrating security issues;
- time synchronization of the single network nodes;
- auto-localization of each node in case of non-structured WSN;
- auto-calibration of each node;
- dynamic reconfiguration of the network if one or more nodes fail, fault tolerance;
- computing performance and mote memory capacity.

The problematic of WSN belongs to the main point of interests in the European Union and it is planned to be included in the HORIZON2020 Seventh Framework Programme. Broad WSN application domains include following branches:

- Transportation & Infrastructure;

- Health-care;
- Environment monitoring;
- Precision agriculture;
- Industry application;
- Security systems and Surveillance;
- Home automation ;
- Military and other.

2. Inteligent Transportation Systems

The transportation sector could be considered one of the most important branches of modern life. It could be even said that it belongs to the core sectors of the European Union since it employs around 9.1 mil persons (4.5% of the total labour force) with the total provision for operating companies for about 4.6% of total Gross Value Added (€520 billion) [10]. U.S. ITS market revenues are estimated for about $48 billion in present days and exceed those for electronic computers, motion picture and video products, direct mail advertising, or internet advertising [11]. Therefore, reasonable activities in transportation field could have significant impact on economy growing. On the other hand, disadvantages arising from the vehicles' number as well as traffic volume growing bring along tough problems of health or environmental character (e.g. traffic accidents, pollution, traffic jam…). In order to solve these problems, international organizations, governmental authorities, industry corporations have been putting effort into supporting of applying electronics, information and communication technologies in the field of transportation, so that Intelligent Transport Systems, became reality [11].

Regarding the key application classes of ITS, which are safety, effectiveness, ecology and comfort, WSNs provide a unique methods for their improvement. It is obvious that monitoring and control of especially the road traffic requires collection of information from many sensors which are appropriately distributed in large scale zone [11]. This is the reason of why the research and development has naturally focused on implementation of wireless sensor networks in real transportation applications. In general, it is possible to state that WSN are applicable everywhere where distributed information resources are available. The typical applications of nowadays, integrating WSN into ITS, are mainly oriented into the problematic of vehicle classification, traffic-flow monitoring, ventilation management, parking navigation at wide spaces and monitoring of environment solid particles.

Referring to required functions and parameters of WSN for ITS, the following sensor node prototypes have been developed at the Department of Technical Cybernetics.

1) **WSN node for the vehicle classification according to the acoustic signal at 15 kHz together with vibrations at 1000 Hz analysis (Fig. 1) [12].**
   - sensing part consists of microphone MCE100, preamplifier, second order anti-aliasing filter and 3-axis accelerometer MMA8453;
   - control unit comprises 32-bit microcontroler STM32F100s in LQFP48 package with ARM-Cortex M3 core operating at max. 24MHz;
   - the node takes an advantage of XBee PRO communication module operating at 2.4 GHz ISM. The node incorporates microSD card slot as well.

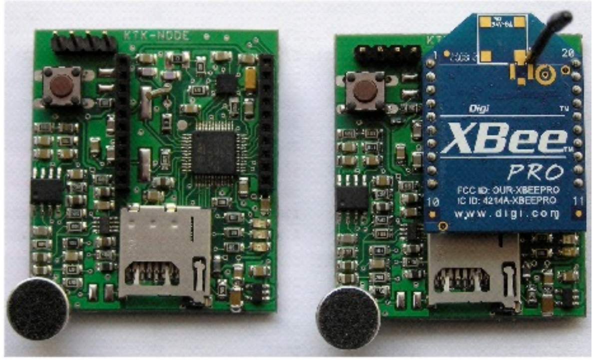

Fig. 1 WSN node for vehicle classification based on the acoustic signal and vibration analysis

2) **WSN node for the vehicle classification according to the magnetic signal analysis (Fig. 2) [13].**
   - sensing part of the node consists of the sensor LSM303 containing magnetometer with an accelerometer;
   - communication subsystem based either on a module RFM70 (2 Mbps) or Xbee (250 kbps) in the ISM 2.4 GHz;
   - control unit comprises ARM Cortex™-M3 32-bit RISC core microcontroler STM32F100RB;
   - data storage is provided by micro SD card;

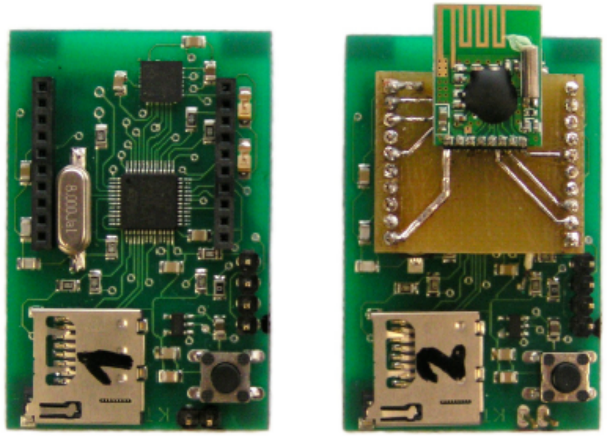

Fig. 2 WSN node for vehicle classification based on magnetic signal analysis

3) Experimental node for parking space detection (Fig. 3).

- sensing part based on ultrasonic sensors, alternatively on optical sensors, PIR or magnetometer.

Fig. 3 Experimental node for parking space detection

All of the sensors apply in general almost the same block structure as shown in the Fig. 4 [12].

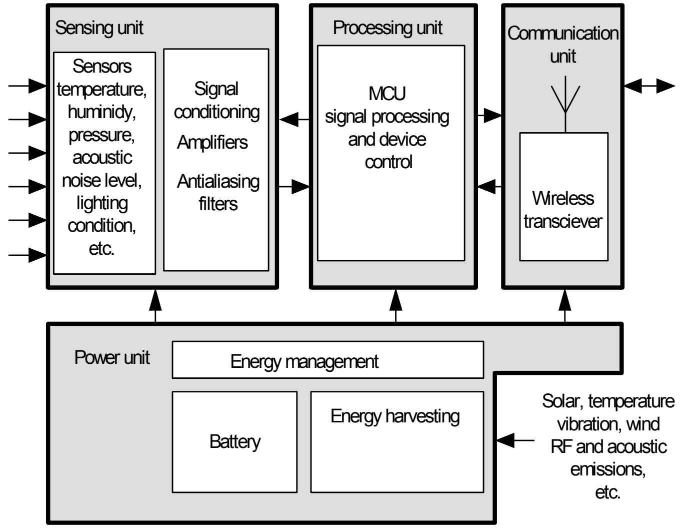

Fig. 4 Basic block structure of the sensor node

3. Case Study

With reference to the above mentioned, targeting one of the biggest transportation problems, the new concept of WSN is being developed at the current time. WSN is planned to be employed in road transportation solving the problem of vehicle detection at places or situations where it is critical. The sensors will be placed at the locations with quite high risk of crash to inform traffic participants about possible danger. These places can be distinguished by blocked view on actual traffic situation (Fig. 5) or by specific conditions making the guidance of traffic participants important, as e.g. guidance of blind, visually impaired or elderly people (Fig. 6).

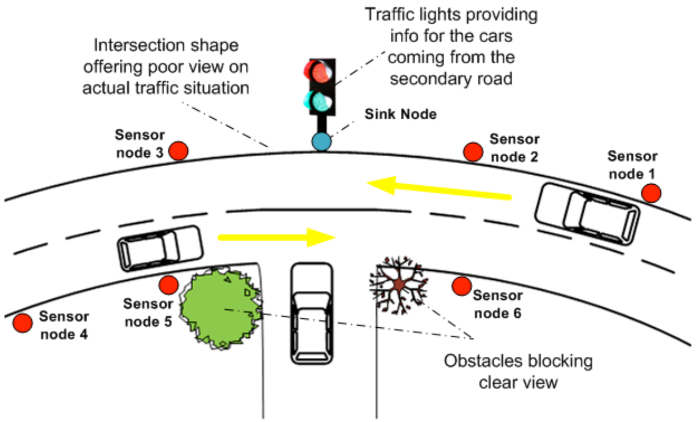

Fig. 5 Traffic situation with blocked view

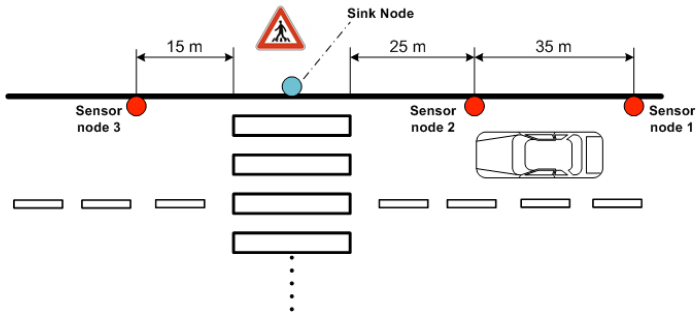

Fig. 6 Specific traffic guidance demanding situation

For this purpose, it is being developed a special sensor node comprising TI ultra-low-power mixed-signal microcontroller MSP430F2232, ultra-low-power TI Sub-1GHz RF Transceiver CC1101 and small, low-power, digital 3-axis magnetometer MAG3110 (Fig. 7).

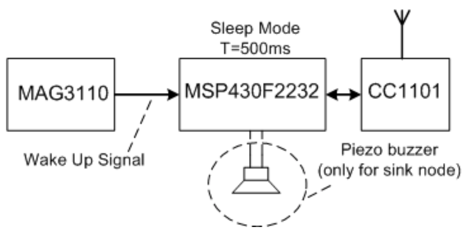

Fig. 7 Block schematic of proposed sensor node

The sensors will be deployed along the edges of desired roads with distribution dependant on the maximal speed limit applied for vehicles driving within the area. Since the typical application scenario is situated inside the cities where the maximal speed limit is 50 km/h, WSN consisted of three nodes spaced app. by 20 meters apart from each other will be sufficient to be implemented for reliable vehicle detection. The network will be able to detect vehicles even exceeding speed limit and driving up to 50 m/s. Particular sensor nodes will be integrated into the pavement marker chassis, thus the high resistance as well as lifespan of the single nodes will be secured Fig. 8

Fig. 8 Chassis of the sensor nodes

Long life-time of nodes is caused by implementation of suitable sensing, management and communication methods. Chosen control unit, microcontroller (MCU) MSP430F2232, initiates communication in 500 ms time slots, when turning into the sleep mode in between. Ultra-fast wake-up from standby mode, with power consumption 0.7 µA, to active mode (270 µA at 1 MHz, 2.2 V) in less than 1 µs allowing actuation of the control unit also by utilization of the magnetometer interrupt signal [16]. MAG3110 will be due to the integrity reasons still in the active mode with power consumption 137.5 µA at output data rate 10 Hz (VDD = 2.4 V, VDDIO = 1.8 V, T = 25°C) [14]. However, by turning the magnetometer to the standby mode (Turn-on time 25 ms, power consumption 2 µA), other power savings could be reached. The MAG3110 measures the three components of the local magnetic field which will be the sum of the geomagnetic field and the magnetic field created by components on the circuit board. After MCU waking up, pre-processing will be performed within the MCU and according to the results achieved the communication module can be initiated. This facilitates avoiding of false detection messages. Communication module CC1101 will be implicitly kept in the sleep mode with current consumption 100 µA and relatively fast startup time 240 µs. After MCU initiates communication, CC1101 will switch to the active mode with power consumption 15.6 mA in receive mode at 250 kBaud and 30.0 mA in transmit mode operating in ISM 868 MHz [15]. Integration of suitable compact-size battery, such ER34615/SAFT LSH20 3.6V primary high energy lithium thionyl chloride D Size battery with nominal capacity 19 Ah @ 3.0mA 20C 2.0V, allow keeping of desired working time of node, which was assigned to one year.

The method for channel access will be based on the sharing of the same frequency channel by dividing the signal into different time slots. Thus the transmission medium will be shared by using only a part of its channel capacity. The communication time interval defined to 1000 ms will be divided into 1024 slots (0...1023). Then the transmission of packet will be done in one time slot, though the packet receiving will be done for better reliability in 3 time slots (2,3,4). Slots 0 and 1 will be assigned for packet detection. In all other slots, MCU will stay in LPM3 mode, when only timer and interrupt controller for handling the wake-up signal of magnetometer remain active (Fig. 9).

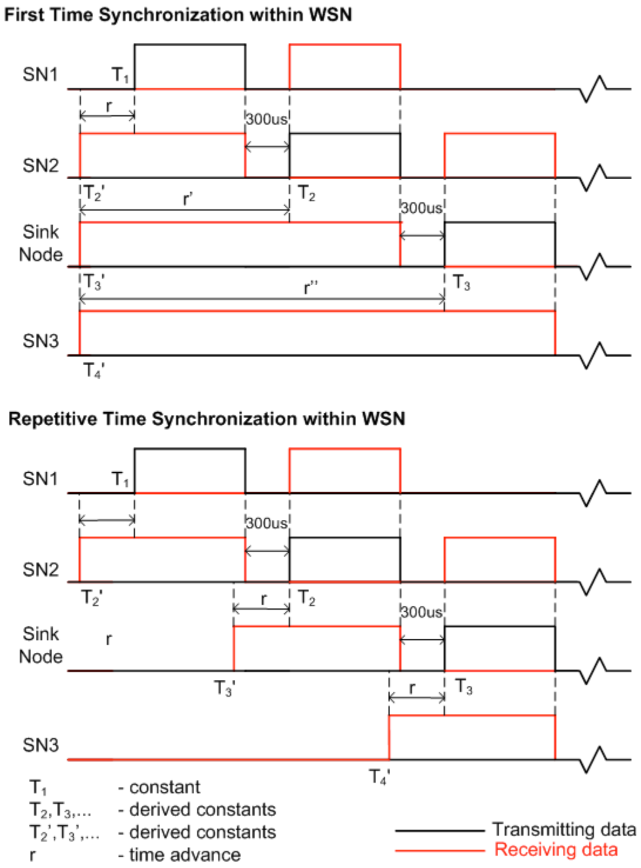

Fig. 9 Time synchronization within the network

All transmitted data will be grouped in the packet of 6 bytes size comprising info about packet ID, address (source/destination), time stamp and CRC. Info about time of vehicle detection will allow distinguishing of vehicle's speed. For powering of the sink node will be utilized method of energy harvesting as described in [17].

4. Conclusion

Proposed WSN will be implemented within the Centre of excellence for systems and services of intelligent transport set at the Faculty of Management Science and Informatics, University of Žilina. The WSN could significantly improve traffic safety as the unique platform considering guidance of physically impaired persons within critical places of city centres. Keenly price of the sensor node, expected bellow 20€ with battery included, could allow global expansion of the network over the world. The WSN will provide important mean for the traffic safety improvement.

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Biographies

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Juraj Miček (prof, Ing, PhD) was born in 1952. He graduated in 1976 from Faculty of Electrical Engineering at the Slovak Technical University, Bratislava. He received his PhD degree in Technical Cybernetics from University of Transport and Communications, Žilina in 1985. He is head of the Department of Technical Cybernetics, FRI, ZU in Žilina. The main topic of his present research activities is digital signal processing and automatic control theory. He is the chairman of FedCSIS IEEE International Conference on WSN.

Michal Chovanec is a student of the Faculty of Management Science and Informatics at the University of Žilina currently studying for his master's degree in the field Computer engineering with diploma thesis "Development of operating system for M3 and M4 ARM Cortex processors supporting preemptive multitasking". The main topics of his current research include problematic of artificial intelligence fusing neural networks, genetic algorithms and fuzzy logic.

Survey on Mobile Cloud Computing – Challenges Ahead

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Abstract
Today, more users are becoming dependent on the mobile tools (e.g. smartphones) as their primary computing device, replacing the traditional stationary PCs. However, there is a major obstacle for further development; the resource-paucity of mobile devices. Mobile Cloud Computing is intended to provide services to mobile users by supplementing the resource-paucity of mobile devices, i.e. off-loading tasks and data on the Internet and providing the resources to a local client on-demand. In parallel, 4G network technology LTE/LTE-Advanced has just been rolled out in the global market. Despite LTE´s improved network quality, much needs to be done before the Mobile Cloud Computing can reach its true potential. Therefore, the overall objective of this paper is to characterize the network behavior of Mobile Cloud Computing, which allows us to address fundamental Mobile Cloud Computing challenges.

1. Introduction.

Today, mobile tools, such as smartphones and tablets, have become primary computing devices for many users and begun to replace traditional stationary PCs. Mobile Cloud Computing is intended to provide services to mobile users by supplementing the resource-poor nature of mobile devices, i.e. offloading tasks and data on the Internet, rather than on individual devices, and providing the resources to a local client on demand. This way, mobile devices do not require a powerful configuration.

In parallel with the rise of Mobile Cloud Computing, the state-of-the-art 4G (fourth generation) network technology, LTE/LTE-Advanced has just been rolled out in the global market. LTE's improved network quality and user experience is expected to deliver the innovative Cloud-based new mobile multimedia services, which will benefit both end-users and businesses. However, much needs to be done before the Mobile Cloud Computing can reach its true potential. The main obstacles we need to tackle include the device battery lifetime, interaction latency, and the quality of service/experience (QoS/QoE), and seamless handover, which are intrinsic problems in wireless mobile communications.

Here, is a brief survey on the up and coming trend, Mobile Cloud Computing with specific emphasis on the 4G wireless network LTE/LTE-Advanced in the Cloud environment.

2. Mobile Cloud Computing

It is a rapidly growing trend that more users are becoming dependent on the mobile tools as their primary computing devices and replacing the traditional stationary hardware. As the features for handling multimedia (images, videos, music, and other media) are integrated into the Smartphones today, the mobile-only Internet population is projected to grow up to 788 million people worldwide by 2015 [1]; hence the impact of the mobile communication market on the global economy is obvious. However, there is a major obstacle for further development of mobile communication, i.e. mobile devices are resource poor relative to stationary hardware.

It is because of the:
1) restricted computing power due to the small battery capacity,
2) limited processing power and memory of mobile hardware, and
3) resulting limitation in executing resource-hungry user applications.

Hence, a logical and obvious solution is to leverage Cloud Computing. With Cloud Computing, the resource-intensive applications can be stripped out of the mobile devices and out-sourced for remote execution over the Internet.

Cloud Computing has become an important paradigm for delivering shared resources on-demand (e.g., infrastructure, platform, software, and so on), to a user's devices (e.g. computer or mobile device) over the Internet. End-users can access Cloud applications through a web browser or a light-weight desktop or mobile app. While the software and data is stored on servers at an unknown remote location, the end-users can receive the same, or better, level of service and performance, as if the software programs were installed on their local computing device. Synergy between these features of Cloud Computing, mobile computing (As shown in Figure 1) through portable devices and wireless/wired networking is termed Mobile Cloud Computing (MCC).

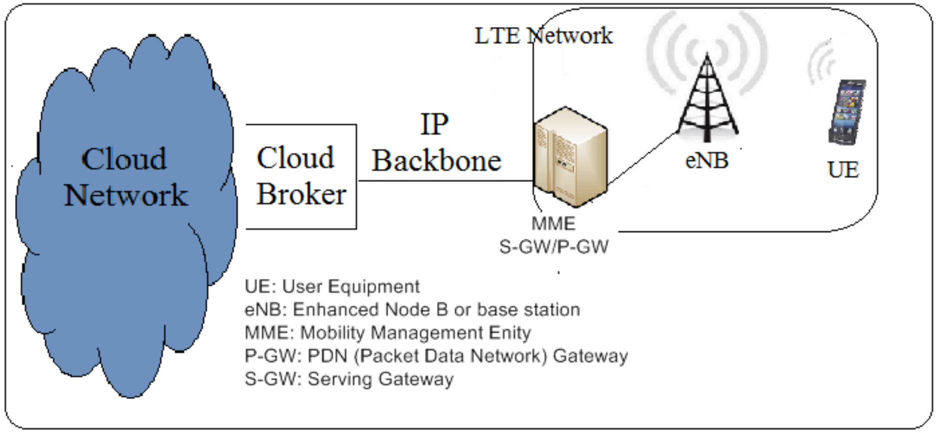


Figure 1 End-to-End Mobile Cloud with LTE

In MCC, all the data and complicated computing modules can be processed in the Cloud and thus, mobile devices do not require a powerful configuration such as high CPU speed and large memory capacity. MCC grows with the development of Mobile applications (apps) and MCC is expected to become the leading mobile application development/deployment strategy. Today, some popular mobile Cloud apps have already been in use, such as mobile Gmail and Google Maps. The Cloud app-users can access applications from a Cloud-based location via their handset's browser or applications, which enables richer functions with less handset resource consumption. Another advantage is that Mobile Cloud apps can be created on Cloud-based platforms and delivered to any device unlike non-Cloud apps, where different versions of one application have to be built for each device. Therefore, MCC together with Mobile Cloud apps are rapidly growing segment in the global market.

Soon, mobile broadband speeds are expected to match DSL speeds with advancement of 4G technologies such as LTE/LTE-Advanced. Ever since the world's first publicly available LTE service was launched in Stockholm and Oslo in 2009, LTE has gained popularity and is anticipated to become the first truly global mobile phone standard. The LTE (specified in the 3GPP Release 8 and 9 document series) is commonly referred to as 4G wireless service in the market. Technically speaking, it does not satisfy the requirement defined by ITU-R organization, and thus in some cases, classified as pre-4G. The LTE-Advanced standard, on the other hand, satisfies the requirements to be 4G and the standardization was finalized in 2011. (In order to avoid confusion in terminology, in this paper henceforth, we consider both versions of LTE as 4G and refer to them as LTE/LTE-Advanced).

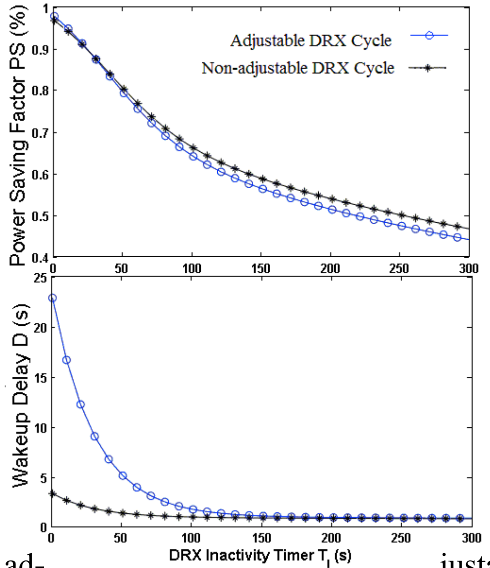
Shortly, data rates of 50 Mbps will become common-place; the access speed of 4G will enable new revenue-generating services. Not surprisingly, an increasing number of operators are now offering Cloud-based services with 4G LTE/LTE-Advanced in mind. LTE's higher bandwidth capabilities, nearly ubiquitous broadband access and improved quality of user experience have the potential to deliver the innovative Cloud-based mobile multimedia services with fast, cost-effective, accessible, and scalable deployment.

3. Challenges in Mobile Cloud with 4G

However, much needs to be done before the MCC can reach its true potential. The main obstacles we need to tackle include the device battery lifetime, interaction latency, the resulting quality of service/experience (QoS/QoE), and seamless handover.

Energy efficiency: For all Mobile Cloud Computing scenarios, energy consumption in battery-powered devices is a key issue [2].

One aspect of the argument is that Cloud Computing enables computation by off-loading from the device and thereby reducing energy consumption of the mobile device. For example [3] simulated the system and found that, under certain conditions, 20% energy savings would be achieved. However, the remote computing in the Cloud consumes substantial energy for wireless communication. Therefore, there is a trade-off between communication energy and computing energy, which determines the balance of local (mobile device) versus remote (Cloud) computing.



As seen in Figure 2 a model for the LTE Discontinuous Reception (DRX) mechanism with adjustable and non-adjustable DRX[1] cycles using a semi-Markov process and tested it with bursty packet data traffic is presented. In Figure 2 show the performance differences between adjustable and non-adjustable DRX in the Inactivity Timer (T_I), the Short Cycle Timer, and the Long Cycle Timer, in terms of the power saving factor and wakeup delay. The figures depict power saving factors and wakeup delay in the DRX Inactivity Timer, with either adjustable or non-adjustable DRX, by means of a Semi-Markov model. The analytical model shows there is a trade-off between energy saving and delay (or latency) for DRX. There is a need to investigate the trade-off relationship of off-loading versus local device computing in a Mobile Cloud with LTE/LTE-Advanced.

Figure 2 LTE Power saving and Delay

There are additional elements which would affect the break-even point between communication energy and computing energy. For instance, newer standards for wireless communication, LTE/LTE-Advanced include energy efficiency requirements. The mobile device by itself can have a scheduling mechanism for energy efficiency, in which the device goes through awake/sleep cycles with the machine turning off automatically when it is not used [4], [5], [6]. How such functions in LTE influence the total energy efficiency should be investigated as a prerequisite for wider implementation of Mobile Cloud Computing.

Latency: Interaction latency refers to the delay that users experience between generating some input and seeing the result on their display [7]. This delay is inevitable in Mobile Cloud since the mobile device must communicate with the server even for the most trivial operations. It is particularly problematic as users are accustomed to the responsive interface of traditional desktop applications and will expect same level of interactivity in Mobile communications.

In Cloud architecture, remote display protocol data needs to traverse numerous links and multiple network elements, each of which introduce additional propagation and transmission delays to the end-to-end path. Moreover, the wireless mobile setting induces additional transmission delays due to the limited bandwidth. This limited bandwidth, however, is expected to improve over time. LTE/LTE-Advanced, for example, sets the bandwidth requirement of the downlink at 100Mbit and the uplink at 50Mbit. Thus, bandwidth-related latency, *per se*, can be reduced to a certain degree. Nonetheless, there will *always* be a trade-off between latency and other aspects of networking, such as energy efficiency, security, and manageability [4], [6], [8]. Thus, Mobile Cloud latency under new wireless communication standards needs to be addressed.

Quality of service/experience (QoS/QoE): QoS technologies have been developed and deployed to overcome several constrains in computer networks, including low throughput, packet-drop, bit errors, latency, jitter, and out-of-order delivery. As Mobile Cloud services are often affected by many specific factors including hardware and software limitations of mobile handsets, signal strength of mobile networks, mobility of mobile users, provisioning of QoS assurance in Mobile Cloud environment requires more advanced mechanisms.

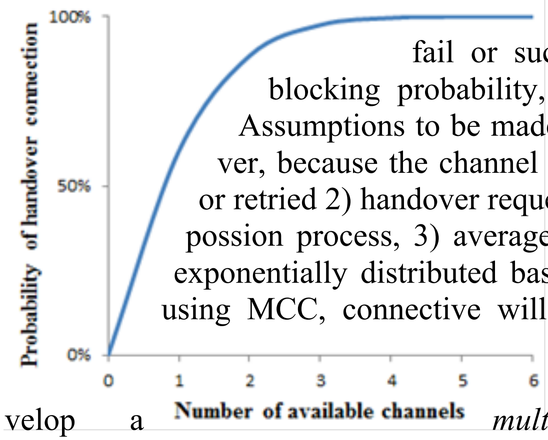
Current Cloud algorithms select the best operator based on the traditional static QoS parameters such as end-to-end delays [10], [11], [12]. Instead, Mobile Cloud should consider adaptive mechanisms [4], [5], [6], [9] in the regulation process. While the traditional QoS parameters are used to objectively measure

[1] To extend the user equipment battery lifetime, plus further support various services and large amount of data transmissions, the 3GPP standards for LTE/LTE-Advanced has adopted discontinuous reception (DRX).

the network quality, a more recent concept, called Quality of experience (QoE) has become commonly used to represent user perception. Cloud-based QoE metrics should include parameters involved in the quality of the user experience such as delay before first image (the time it takes to see the first image of a streaming flow), video fluidity (i.e. average number of frames per second) and its variance, stream breakdown times, coding quality, and the size of the video stream window.

Although the up-and-coming LTE/LTE-Advanced has its own QoS features, it does not consider either Cloud-based adaptive regulation mechanisms or QoE parameters. Implementation of QoE with LTE in Cloud environment is a new field to be explored.

Handover: In contrast to wired network using physical connection, the data transfer rate in MCC environment is dynamically changing and bandwidth consistency are not always ensured. Continuous service in mobile communications is achieved by supporting handover from one cell to another. Handover is initiated either by crossing a cell boundary or by deterioration in quality of the signal in the current channel. Thus, poorly designed handover schemes will lead a dramatic decrease in QoS/QoE [13].



As shown in Figure 3 to predict fail or success of handover connectivity, or blocking probability, by utilizing Erlang loss formula. Assumptions to be made include 1) an unsuccessful handover, because the channel in target cell is busy, is not queued or retried 2) handover requests are independent and following a possion process, 3) average throughput (or average delay) are exponentially distributed based on Markovian system. Despite using MCC, connective will still decrease should the need of channel resources are not available. Therefore, there is a need to develop a *multiple-cell* model to improve QoS/QoE handover performance in an end-to-end MCC.

Figure 3 Handover in MCC

Typically in Cloud, data center and resource in Internet service provider are remotely located from end users, especially from mobile device users. Thus in MCC, the network latency delay in last mile is inevitably larger than traditional wired network. Furthermore, several factors including dynamically changing application throughput and user mobility will also lead to bandwidth fluctuation and network overlay.

Another MCC specific challenge, Off-loading of the tasks can also contribute for network handover delay. Meanwhile, to ensure minimal handover interruption time, LTE/LTE-Advanced has robust general minimum radio resource management requirements. LTE's Mobility support for user equipment (UE) in connected-state comprises of two types of handover procedures: backward handover and Radio Link Failure (RLF) handover, and both procedures require the source Enhanced Node B or base station (eNB) to prepare a target cell for handover concurrently with the handover decision. Interaction between the advanced handover techniques for LTE/LTE-Advanced system and the unique handover challenges in MCC environment should be studied.

The question is "How to achieve seamless handover in wireless mobility provided by LTE/LTE-Advanced and MCC, which comes with constantly changing environment with dynamically fluctuating traffic behavior?"

4. Conclusion

Frontier research needs to be conducted now for MCC to maximize its potential as the Mobile Cloud ecosystem is rapidly evolving globally. The Studies should address the following fundamental challenges: device battery lifetime, interaction latency, the quality of service/experience (QoS/QoE), seamless handover.

For example, our group has been studying LTE/LTE-Advanced energy saving mechanisms [4], [5], [6], [9] and aiming to apply this knowledge to characterize MCC network behavior. In other words, we should study end-to-end whole architecture of MCC, instead of previous approaches focusing on either Cloud or 4G individually.

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Biography

Dr. Scott Fowler received a B.Sc. from Minot State University, USA in 1998, a M.Sc. from the University of North Dakota, USA in 2001 and a Ph.D. from Wayne State University, USA in 2006, all degrees in Computer Science. During 2006 – 2010, he was a Research Fellow in the Adaptive Communications Networks Research Group at Aston University, UK and Sony Ericsson R&D lab, UK, where the research focused on multiple services in Next Generation Networks (NGNs) in both wireless and wired, and the project team was composed of multi-disciplinary/multi-institutional partners from industry and academia. Since 2010, he has been an Associate Professor at Linköping University, Sweden, and works with the Mobile Telecommunication (MT) group. Dr. Fowler has served on several IEEE conferences/workshops as TPC to Chair. His research has been funded and supported by European Union Framework 7, Excellence Center at Linköping - Lund in information Technology (ELLIIT), Ericsson and Ascom. Dr. Fowler's research interests include Quality of Service (QoS) support over heterogeneous networks, Computer networks (wired, wireless), Energy management, Mobile Computing, Pervasive/Ubiquitous, Performance Evaluation of Networks and Security. In 2012 he was awarded a Visiting Professorship from the France Scientific Council to the University of Paris-Est Creteil (UPEC), France. Dr. Fowler was a host for a Fulbright Specialist from the USA in 2011. He is a member of IEEE and ACM.

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