ABSRJ Advances in Business-Related Scientific Research Journal

geacollege Faculty of Entrepreneurship

ANALYSIS OF DISRUPTIVE SIM TECHNOLOGIES USING BUSINESS ECOSYSTEM CONCEPT

Thanh van Do*
Telenor Research & Norwegian University of Science &Technology, Norway
thanh-van.do@telenor.com

Hanne Stine Hallingby
Telenor Research, Norway
Hanne-k.hallingby@telenor.com

Patrick Waldemar
Telenor Research, Norway
patrick.waldemar@telenor.com

Abstract

The SIM card has lately experienced a lot of technology changes in terms of processing, storage, interface, form factor, etc. Typically it is getting smaller, may even in the near future disappear totally and then be reborn as something else. Unfortunately, it is not trivial to determine which SIM innovations are sustaining or disruptive to mobile operators. This paper proposes a methodology based on the business ecosystem concept to analyze the SIM technology advances. The paper proposes a methodology using the business ecosystem concept for systematic identification and analysis of technology innovations. The determination of the sustaining or disruptive character of an innovation is based on a comparison and logical deduction of positive and negative impacts. The SIM technology innovations are identified and assessed thoroughly and both sustaining and disruptive innovations are determined. Last but not least recommendations to meet the identified disruptions are provided.

Key Words

Disruption analysis; disruptive innovation; business ecosystem; SIM, identity management.

*Corresponding Author

INTRODUCTION

From its birth for a little bit over two decades ago until today, the SIM card, this familiar tiny piece of plastic that inserted into any mobile phone enables people to make phone calls, has encountered tremendous changes. It has evolved in terms of size from mini, micro to nano format and in terms of processing power, storage, interface, etc. Mobile operators as the owner of this element are quite interested in knowing what SIM innovations could be beneficial or nocuous to their business. According to Christensen (Christensen 1997; Christensen and Raynor 2003; Christensen, Anthony, and Roth 2004) these changes could be of two innovation types: sustaining innovations and disruptive innovations. Sustaining innovations, as defined by Christensen, are often innovations that occur frequently and are implemented by established large companies in order to improve the performance of some of their products that have strong market shares. Disruptive innovations occur less frequently and tend to have performance problems initially although they are often less expensive, simple and more convenient to use. Disruptive innovations can destabilize existing markets and may result in the failure of well-established players. Consequently, the established firms are interested in assessing the disruptive potential of new innovations. Unfortunately, according to Nabil (Nabil S. & van de Bunt-Kokhuis S. 2012), it is not always easy to determine whether an innovation is sustaining or disruptive or both. To address the last issue this paper proposes a methodology to identify and analyse disruptive technologies which is based on the concept of business ecosystem. Although the method is intended for the analysis of the SIM card it is sufficiently generic to be used for other technologies, products or services. The paper starts with an overview of the SIM. Next, the disruption analysis methodology is thoroughly explained. The main part of the paper is the identification and analysis of the SIM technologies innovations. Recommendations to mobile operators are also provided.

OVERVIEW OF THE SIM

SIM stands for Subscriber Identity Module and was originally specified by ETSI (European Telecommunications Standards Institute) in specification TS 11.11 (ETSI 1989) which was later partially transferred to 3GPP (3rd Generation Partnership Project). It consists initially of both the tamper resistant integrated circuit and its secured content which is the International Mobile Subscriber Identity (IMSI) and the related keys used to identify and authenticate the subscriber on GSM mobile phone. The role of the SIM is to carry out strong authentication of the subscriber before granting access to the GSM network and to prevent cloning or abuse of the subscription.

With the arrival of UMTS it was necessary to separate the hardware module now called UICC (Universal Integrated Circuit Card) and the SIM software application because the UICC is now hosting also another software

application called USIM (UMTS SIM), which is required for the authentication and access to UMTS network.

From a single module the SIM is now divided into two entities:

1. UICC which is the tamper resistant hardware module.
2. SIM which is the software application containing the mobile identity.

These two entities evolve independently and encounter different changes that could be beneficial or disruptive to telecom operators.

DISRUPTION ANALYSIS METHODOLOGY USING BUSINESS ECOSYSTEM CONCEPT

In order to analyse and determine whether a technology innovation is sustaining or disruptive, we proposed a methodology which is based on the business ecosystem concept. The business ecosystem concept suggests to consider a business system as an ecosystem in the same way as a biological one and to benefit from the knowledge acquired in the biological ecosystem (Anggraeni et al., 2007).

The business ecosystem concept has gained a lot of momentum and there exists a considerable amount of publications about it. Unfortunately, there is not yet a consensus about what exactly a business ecosystem is and there are currently several overlapping and also conflicting definitions (Zhang and Liang, 2011).

To avoid confusion we adopt the definition given by Peltoniemi et al (2005) defining "*a business ecosystem to be a dynamic structure which consists of an interconnected population of organizations. These organizations can be small firms, other parties which influence the system*".

The proposed disruption analysis methodology consists of the following tasks:

1. *Identification of the changes or innovations of the targeted product or service:* In this task it is crucial to identify all the technology advances, direct or indirect, standard or de-facto standard that may affect the targeted product or service.
2. *Specification of the relevant ecosystem and its boundaries*: To be able to understand the impact of the new technology innovation, it is necessary to identify and confine the business ecosystem which is influenced by the targeted product or service. Choosing an ecosystem with too narrow boundaries could lead to a disaster since decisive impact may happen outside. Selecting too wide boundaries may lead to huge waste of effort.
3. *Specification of the ecosystem's seed and its performance attributes*: The crucial task is obviously to recognize the seed around which the ecosystem is built and growing (Battistella et al. 2011, 2013). The seed is the "raison d'être" or reason for existence of the ecosystem. The seed brings life and prosperity to all the players in the ecosystem from the consumers, service providers, device manufacturers, etc. When the seed is threatened the whole ecosystem is in danger. It is

also important to identify and justify the performance attributes that makes the seed valuable for all the players in the ecosystem.

4. *Identification of the technology platform required to providing the seed and its performance attributes:* To be able to offer the seed of the ecosystem and its performance attributes, a technology platform consisting of one or more component is required. It is necessary in this task to place the targeted product or service as for example the SIM, in this technology platform and to find its role in the support of one or more performance attributes. If it is not possible, the selected ecosystem is not the appropriate one and it is necessary to go back to task 3.
5. *Identification of the competing alternatives to the seed:* In this task, a very wide identification should be carried out to find all the competing alternatives to the seed. Their performance attributes have to be identified and studied. Whenever possible links between the targeted product or services and the competing performance attributes should be established to facilitate the next task.
6. *Assessment of the innovations of the targeted product or service as beneficial or nocuous:* For each innovation, the positive and negative consequences for the performance attributes of the ecosystem seed as well as the ones of the competing alternatives are identified. If the positive ones for the ecosystem's seed and the negative ones for the competitors are dominant the innovation is favourable. Otherwise, it is disruptive. Counter measures could also be proposed to the ecosystem's central player – also called the keystone (Iansiti M., Levien R. 2004).

Let us now proceed with the disruption analysis of the SIM technologies.

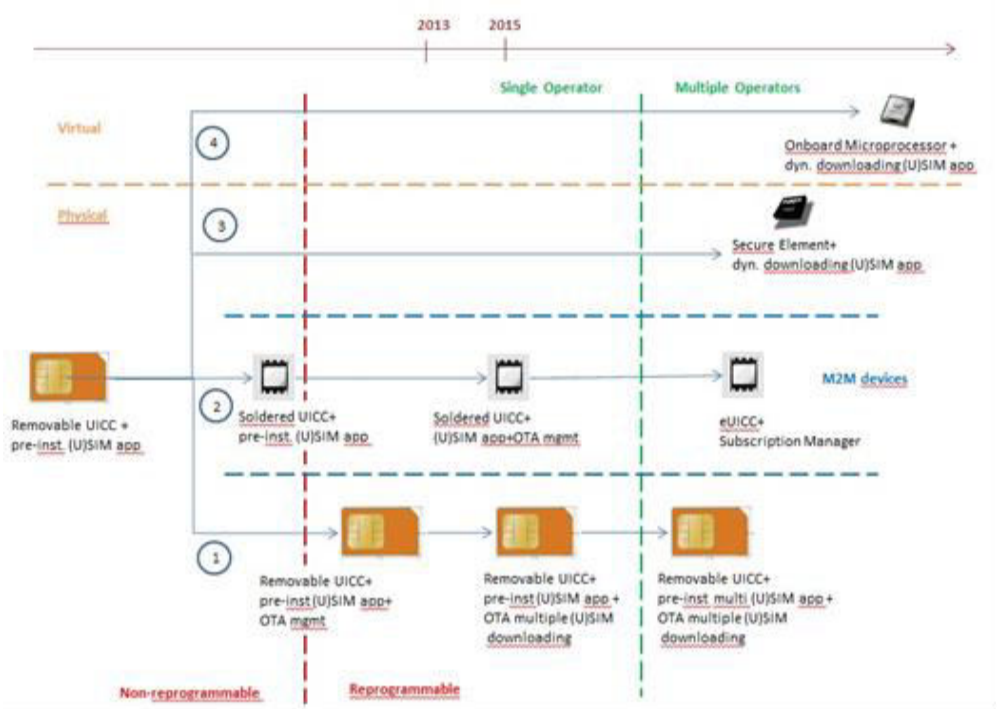
IDENTIFICATION OF THE INNOVATIONS OF THE SIM

Since the SIM card consists of the UICC and the SIM applications the identification of innovations will be done successively for both of them.

Innovations of the UICC

The evolution of the SIM was not happening in a structured way and controlled by one player or organisation but in a rather chaotic and confusing one. It is difficult or perhaps not possible to find documentation providing the whole picture but only fragments of it. Consequently, the description given here is the result of thorough collection and studies of qualified documents (Vedder 2009, 2011) and information presented at Web sites of SIM and semi-conductor manufacturers.

Figure 1: Evolution of the UICC



As shown in Figure 1 the UICC evolution follows four paths as follows:

1. The UICC will remain to be removable and provide flexibility to the user. It is still own by single operator. The most important improvement is the Over-the- air (OTA) management that turns the UICC programmable from a non- programmable module. Starting with minor modifications of subscription it is gradually possible to change a whole subscriber profile or to download new SIM/USIM applications. Further the removable SIM may also host SIM or USIM applications from different operators. This is possible today even without standardisation but commercial agreements need to be in place between this group of mobile operators that decide which SIM/USIM should be used at each time and how to switch between them.
2. This evolution path arises from the machine-to-machine (M2M) domain where there is a need of initialising communication with a large number of distributed devices e.g. metering devices, sensors, industrial automation, etc. without having to reach and install the SIM cards. Furthermore, M2M devices are quite often exposed to rough situations such as high temperature, noise, humidity, vibration, etc. and the removable UICC might not be the not be the most appropriate form factor because of its dependency on the card reader and its contacts that could deteriorate due to corrosion. It is hence desirable to have soldered in the M2M device a solid UICC that has longer lifetime than a regular SIM.

The current version of the UICC came with pre-installed SIM/USIM. However, with the OTA management it will be possible for the mobile operator to carry out modifications on the subscriber profile or to download a new profile on the UICC.

Since M2M manufacturers do not know where the produced devices will be rolled out they will have problem to install the right UICC with the right SIM. There is an obvious need to be able to select mobile operator and download the wanted SIM long after fabrication.

In order to ensure neutrality and fairness, e.g. all mobile operators can be selected at the same time as fraud and abuses, e.g. the SIM could not be cloned and re-used or at confidential data are extracted, standardised measures have to be agreed and introduced. The standardisation of the eUICC (embedded UICC) initiated by GSMA is now fueled by the ETSI SCP (Smart Card Platform). Unfortunately, the work is progressing slowly due the conflicting interests that the participating members have.

3. The UICC is replaced by a Secure Element which is hosting the SIM/USIM application. A secure element (SE) is a tamper-resistant platform (typically a one chip secure microcontroller) capable of securely hosting applications and their confidential and cryptographic data (e.g. key management) in accordance with the rules and security requirements set forth by a set of well-identified trusted authorities. The GlobalPlatform (2010) defines three different form factors of SE: Universal Integrated Circuit Card (UICC), microSD and Embedded SE.
4. The UICC is replaced by a secure zone built inside the microprocessor chip. A typical example is a chip from Trustonic (2014) integrating a Trusted Execution Environment (TEE) (GlobalPlatform, 2011) on a secure ARM TrustZone (ARM, 2009).

Innovations of the SIM application

Originally, inside the UICC there was only the SIM application that contains the user's credentials for authentication and authorization to the GSM network. Afterwards the USIM emerged with the arrival of UMTS or 3G. Both the authentication and the ciphering methods are constantly improved to provide higher security. The SIM/USIM will always be the one and only module responsible for security in the mobile networks and there is no change to envisage. It is also worth noting that the SIM/USIM is not much used for authentication of other services such as WLAN or Internet services although there exists standards or industry solution such as Extensible Authentication Protocol (IETF, 2006) combined with 802.11x (IEEE, 2010), Generic bootstrapping Architecture (3GPP, 2007), SIM strong authentication (Do, v. Thanh et al. 2006.2008), etc.

SPECIFICATION OF THE RELEVANT ECOSYSTEM AND ITS BOUNDARIES

The SIM card could be placed within several ecosystems such as the SIM card ecosystem, mobile payment ecosystem, NFC (Near Field Communication). However, since our goal is to determine changes that could be disruptive to mobile operators the business ecosystem to be considered should be the mobile communication ecosystem. The main justification to select the mobile communication ecosystem lies in the fact that although it could be used in other application area, the SIM was invented for mobile communication systems and for ensuring the security of mobile services.

SPECIFICATION OF THE MOBILE COMMUNICATION ECOSYSTEM'S SEED AND ITS PERFORMANCE ATTRIBUTE

To determine the seed of the mobile communication ecosystem is not a simple task because the ecosystem is constantly evolving and the services it is offering is changing dynamically. By considering the services that bring the most revenue to the mobile ecosystem we consider the seed of the mobile communication ecosystem as consisting of the two communication services, namely voice communication and short message service (SMS).

In order to specify the performance attributes (Christensen, C.L, 1997, Bower, J.L, Christensen C.M, 1995) of the mobile communication seed we carried out a thorough analysis of the two mentioned main services to find out the characteristics that make them attractive to the users. The attractiveness of the mobile communication seed is reflected by the following performance attributes:

Ubiquity: The two services should be available everywhere

- Reliability: They should be available 99,99% of time whenever the user needs.
- Mobility: The services should be functioning while the user is moving both in low and high velocity.
- Trust: The user should be able to trust that communications, e.g. voice or message are done with the right interlocutor.
- Security: The communications are protected against disclosure to unauthorized third party.

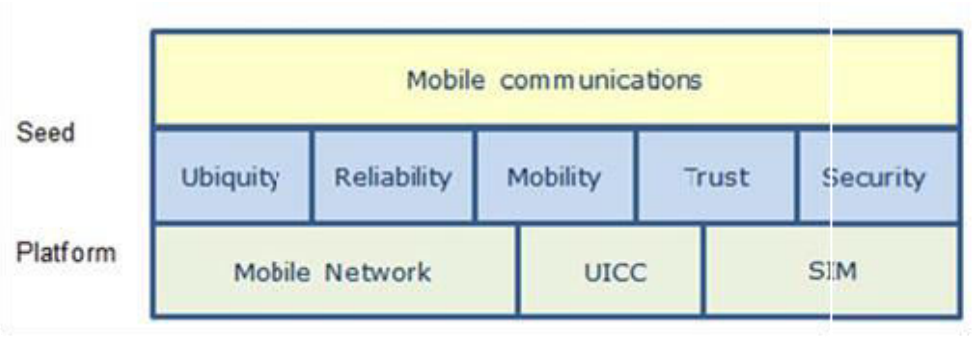
IDENTIFICATION OF THE TECHNOLOGY PLATFORM REQUIRED TO PROVIDING THE SEED AND ITS PERFORMANCE ATTRIBUTES

As shown in Figure 2 to obtain and maintain the mentioned performance attributes the mobile communication ecosystem must have an adequate technology platform, which consists of three components:

- The mobile network that ensures Ubiquity, Reliability and Mobility.

- The UICC that provides Mobility (portability between handsets) and Trust with its tamper-resistant characteristics.
- The SIM that contributes to Trust and Mobility.

Figure 2: The mobile communication ecosystem's seed, performance attributes and technology platform



By using the proposed methodology, the unique and crucial roles of the UICC and the SIM in the ecosystem, which is usually neglected, became very visible. Consequently, any changes of the UICC and SIM will have impact on the seed.

IDENTIFICATION OF THE COMPETING ALTERNATIVES TO MOBILE COMMUNICATION SERVICES

The mobile communication services enjoyed the privilege of being without rivals for over two decades. It was only with the rise of the Internet that the so far healthy mobile ecosystem finally got competition. At early stages the Internet players offered only information and commerce services and were more complementing than competing with the actors in the mobile communication ecosystem. As the Internet was getting more mature IP telephony services also called VoIP services started to emerge in high pace and in high quantity at the same time as social networks such as Twitter, Facebook, etc. provide alternatives messaging (Kopetsky R. et all, 2013).

The competition is becoming more real when the Internet players also allow flexible combinations of telephony and messaging between two users or a community of users. In addition, the possibility of watching their interlocutors i.e. other communicating parties, contributed to make IP telephony, also called VoIP service, quite attractive to a lot of users. But the most remarkable factor is the fact that these IP services are free of charge while mobile communication services are charged based on usage, i.e. per minute or per message. Indeed, most of Internet players adopt a new business model based on advertising revenues (Timmers P. 1998, Rappa M. 2005) and not on subscriptions. Their focus is hence to attract as many users as possible by offering free account. To access their IP communication services, consumers do not use the phone number but digital identities such

as Skype ID, Facebook Connect, LinkedIn, Twitter, etc. By using passwords as authentication these IP telephony services do not yet provide the same level of trust and security as the mobile communication services. In fact, so far the IP services are mostly used in private circumstances and quite often for social and entertainment purposes. They are used in business in a limited way when the communicating parties know each other but official conversations are still conducted using the mobile communication services due to their high level of trust and security.

Having realised the importance of convenient management of communication services for the users Google introduced Google Voice, Google Voice gives the user one number for all phones - a phone number that is tied to the user, not to a device or a location. Google Voice simplifies the way to use phones, makes voicemail as easy as email and customizes the callers' experience. Google Voice works with mobile phones, desk phones, work phones, and VoIP lines.

Well aware of the user identity's crucial role in the battle to win users Google also tried to link all products to the Google account such that its role in the user's life grows more important every day.

Figure 3: Comparison between mobile communication and IP telephony

Performance attributes	Mobile communication service	IP telephony services
Ubiquity	Yes	Yes
Reliability	Yes	Yes
Mobility	Yes	Yes
Trust	Yes	No
Security	Yes	No
Flexible combination voice, video, messaging & other com. scheme	No	Yes
Low price or free of charge	No	Yes
Convenient management	No	Yes

Figure 3 summarizes the performance attributes of mobile communication and IP telephony. While still having lower level of trust and security IP communication services provides three new performance attributes, namely flexible combination, convenient management and low price that mobile communication services are lacking.

ASSESSMENT OF THE SIM CARD INNOVATIONS

Assessment of the UICC innovations

The first innovation path where the UICC will remain removable is very favourable for mobile operators because it contributes to secure the two performance attributes mobility (portability) and security at the same time as mobile operator remain the sole owner with all rights.

In the second innovation path, the UICC will be embedded inside the equipment and may not be own by the mobile operator anymore. However, as long as the standardisation of the embedded UICC (eUICC) ensures a fair and secure management of the SIM application from different operators the two performance attributes mobility (portability) and security will be safeguarded. This evolution is a sustaining innovation for mobile operators.

In the third and fourth innovation path the UICC will be replaced by a secure element or a trust zone inside the microprocessor chip on the devices. These elements could host the SIM application but mobile operators could refuse to allow due to the lower level of security and the risk of losing control of the SIM application in terms of storage, management and usage. As a consequence, mobile operators will miss the opportunity of exploiting these new and more economic secure storages that could be beneficial for their business. A more reasonable approach could be to follow, understand and influence the development of these secure elements such that the appropriate level of trust and security could be ensured. Most menacing for mobile operators, these innovative secure storages could also host other Internet identities like Facebook Connect, Google ID, etc. and help improving the trust and security level of IP communication services. To summarize the innovative secure storage technologies could be both sustaining innovation and disruptive innovation for mobile operators.

Assessment of the SIM innovations

As described in earlier section the innovations on the SIM/USIM are mostly focused on improving the security of the algorithms for authentication, integrity and confidentiality, which is crucial to maintain the performance attributes, trust and security of the mobile communication services. Although there are standards and solutions to extend the usage of the SIM/USIM to other networks like WLAN and services like Internet services, they are not much in use. This stagnation is not beneficial for mobile operators because the usage of SIM as identity for Internet services would pave the way for offering flexible combination of traditional mobile communication services with IP services, one of the three new missing performance attributes. Further, mobile operators will also be able to provide convenient management of different telephony, messaging on multiple devices. Last but not least, more competitive prices could be given due to the efficient combination of technologies. The evolution or more precisely, the lack of evolution in SIM application technologies is therefore disruptive to the mobile communication ecosystem.

CONCLUSION

In this paper a disruption analysis of the SIM technologies has been carried out by using a methodology which is based on the concept of business ecosystem. Since the SIM card is a very small in size and insignificant in price component of the ecosystem technology platform it is quite challenging to find the significance and consequences of its technology innovations for the huge mobile communication ecosystem. Fortunately, with the proposed methodology it is possible to determine whether an innovation is sustaining or disruptive based on a systematic identification of positive and negative impacts on the ecosystem seed and its performance attributes and the ones of the competing alternatives. The determination is deduced logically from the comparison of positive and negative impacts. The methodology proves to be quite efficient because it manages to capture serious but less obvious impacts which could be left unobserved otherwise.

Although intended for the analysis of the SIM technologies the proposed methodology may be applied for other products or services, especially those which does not constitute the main offering but rather an infrastructure component or side product, which follows the main products or services.

The proposed methodology is still in its infancy and could be improved further by applying it for other technology innovations. There are quite a few candidates such as Network Function Virtualization, Dynamic spectrum, Service personalisation, etc. that could be subject for future works.

REFERENCES

Anggraeni, E., Hartigh, E. d., and Zegveld, M. 2007. 'Business ecosystem as a perspective for studying the relations between firms and their business networks', the ECCON 2007 Annual meeting, Bergen aan Zee, October 19–21, The Netherlands.

ARM 2009. ARM Security Technology; Building a Secure System using TrustZone Technology, 2009.

Basole C. Rahul 2009. "Visualization of interfirm relations in a converging mobile ecosystem". Journal of Information Technology (2009) 00, 1–16, 2009 JIT Palgrave Macmillan All rights reserved 0268-3962/09

Battistella C., De Toni A.F. 2011. "A methodology of technological foresight: A proposal and field study", Technological Forecasting & Social Change, Elsevier 2011.

Battistella, C. , De Toni, A. F. and Nonino, F. 2012, "Strategic analysis using business ecosystem dynamic modelling" Paper presented at the annual meeting of the 43rd Decision Sciences Institute Annual Meeting, San Francisco Marriot, San Francisco. http://citation.allacademic.com/meta/p584975_index.html

Battistella C., Colucci K., De Toni A.F. and Nonino F. 2013, "Methodology of Business Ecosystems Network Analysis: a Field Study in Telecom Italia Future Centre", Technologica Forecasting and Social Change, In Press, Elsevier Inc.

Bower, J.L, Christensen C.M, 1995. Disruptive Technologies: Catching the waves. Harvard Business Review January, February 1995.

Christensen, C.M. 1997, The innovator's dilemma: when new technologies cause great firms to fail, Boston, Massachusetts, USA: Harvard Business School Press, ISBN 978-0-87584-585-2.

Christensen, C.M., and M.E. Raynor. 2003. The innovator's solution: Creating and sustaining successful growth. Boston, MA: Harvard Business Press.

Christensen, C.M., S.D.Anthony, and E.A. Roth. 2004. Seeing what's next: Using theories of innovation to predict industry change. Boston, MA: Harvard Business School Press.

Do, v. Thanh, Jønvik T. Do, v. Thuan & Jørstad I 2006. Enhancing Internet service security using GSM SIM authentication; Proceedings of the IEEE Globecom 2006 conference; ISBN 1-4244-0357-X – San Francisco, USA; Nov 27 - Dec 1, 2006.

Do, v. Thanh, Jønvik T., Feng B., Do, v. Thuan & Jørstad I. 2008.Simple Strong Authentication for Internet Applications using mobile phones; Proceedings of IEEE Global Communications Conference (IEEE GLOBECOM 2008), ISBN 978-1-4244-2324-8, New Orleans, LA, USA, Nov 30 – Dec 4, 2008.

ETSI 1989. European Telecommunications Standards Institute. TS 11.11 Specification of the Subscriber Identity Module - Mobile Equipment (SIM-ME) Interface Global Platform. 2010.

Mobile Task Force; Requirements for NFC Mobile: Management of Multiple Secure Elements Version 1.0 February 2010; Document Reference: GP_REQ_004 GlobalPlatform, 2011. The Trusted Execution Environment: Delivering Enhanced Security at a Lower Cost to the Mobile Market; white paper Feb 2011.

GSMA 2013. GSM Association: Rich communication (2013), http://www.gsma.com/rcs/

Iansiti M., Levien R. 2004 1. Keystones and Dominators: Framing Operating and Technology Strategy in a Business Ecosystem.

Iansiti M., Levien R. 2004 2. The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability: Harvard Business School Press, 2004.

IEEE 2010. the Institute of Electrical and Electronics Engineers; IEEE Standard for Local and metropolitan area Networls – Port-Based Network Access Control; 802.1X-2010 (Revision of IEE Std 802.1x-2004)

IETF 2006, RFC4186. Extensible Authentication Protocol Method for Global System for Mobile Communications (GSM) Subscriber Identity Modules (EAP-SIM) Java Community Process 2007, JSR-000177 Security and Trust Services API for J2ME.

Kopetzky R.., Günther M., Kryvinska N., A. Mladenow A., Strauss C., Stummer C. 2013, "Strategic managemet of disruptive technologies: A practical framework in the context of voice services and of computing towards the cloud", Inderscience Publishers, International Journal of Grid and Utility Computing (IJGUC), Vol. 4, No. 1, 2013, pp. 47-59.

Nabil S. & van de Bunt-Kokhuis S. 2012. Organisational culture and cloud computing: coping with a disruptive innovation, Technology Analysis & Strategic Management, 24:2, 167-179, DOI: 10.1080/09537325.2012.647644

Peltoniemi M., Vuori E. 2005, Business ecosystem as the new approach to complex adaptive business environments, Tampere University of Technology

Rappa M. 2005, Business Models on the Web, Managing the Digital Enterprise, 2005.

Sheffi, Y. 2005 "The Resilient Enterprise - Overcoming Vulnerability for Competitive Advantage". ISBN 0-262-69349-6 Cambridge, MA: MIT Press. (2005)

Sheffi Y. 2009, "Business continuity: a systematic approach", Global Business and the terrorist Threat, Harry Ward

Richardson & Peter Gordon, ISBN 1848449356, 9781848449350, Edward Elgar Publishing, 2009

Tian C. H. et all 2008," BEAM: A framework for business ecosystem analysis and modeling" IBM System Journal, Vol 47, No 1, 2008

Timmers P. 1998, Business Models for Electronic Markets, Electronic Markets, Volume 8, Issue 2, July 1998, p. 4

Trustonic. 2014. http://www.trustonic.com/about-us/who-we-are

Vedder, K. 2009. The UICC - The Security Platform for Value Added Services. Presented at 4th ETSI Security WS, Sophia Antipolis, France 13-14 January 2009.

Vedder, K. 2012. The UICC Recent Work of ETSI TC Smart Card Platform. Presented at 7th ETSI Security Workshop, Sophia Antipolis, France, 18-19 January 2012.

Zhang, J., and Liang, X.-J. 2011. 'Business ecosystem strategies of mobile network operators in the 3G era: The case of China Mobile', Telecommunications Policy, Vol. 35, Iss.2, 156-171.