

## Short-Message Service as a Digital Disruptor of Industry

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**Abstract.** Short-message service (SMS) has disrupted several communications ecosystem stakeholders. With this new technology, consumers have adopted new ways to communicate with each other and companies have radically improved their existing processes and ways to deliver their services. Furthermore, SMS has enabled the emergence of machine-to-machine type services. The Disruption Framework is a theoretical model that can be used for identifying the process of technology diffusion from a scientific level to a level of social norms. SMS is found to fit within the model of Disruption Framework. The study reveals that the service has progressed to all levels in the model thus the service has been diffused at an almost maximal manner through the ecosystem. Shifts from one level and an industry to another level can be pinpointed and diffusion into different ecosystem layers can be identified. SMS reached its maturity phase in the early 2000s. However, there are clear indications that novel technologies are starting to disrupt SMS ecosystem stakeholders since early adopters of those new technologies are abandoning SMS.

**Keywords.** Short-message service, Disruption Framework.

### 1 Introduction

Short-Message Service (SMS) is a messaging technology that utilizes the signalling channel of a mobile network to carry user messages. The technology was standardized in the late 1980s together with Global System for Mobile Communication (GSM) standards by the European Conference of Postal and Telecommunications Administrations (CEPT) and the European Telecommunications Standards Institute (ETSI).

Usage volumes of SMS indicate that the technology has had an influence on consumer and business markets (Ficora, 2016). However, there continues to be uncertainty about the extent SMS has been disruptive. This paper studies the history of SMS using the Disruption Framework -model to gain a better understanding about which layers of the ecosystem SMS have actually been disrupted.

The objective of this study is to gain a better understanding about how SMS has diffused into the ecosystems. Furthermore, we attempt to pinpoint which of the ecosystem stakeholders have been disrupted the most due to SMS technology. To achieve the previously mentioned targets we use the Disruption Framework established by Kilkki et al. (2017). Thus, this study functions as a real world sample

for the Disruption Framework theory. The study does not attempt to take a holistic approach but builds indications from the bottom up that SMS as a technology actually followed the theory of the Disruption Framework. To articulate that in the form of a research question:

*How has SMS diffused into the ecosystem and are there any ecosystem stakeholders that have seen SMS as a disruptive innovation?*

The remainder of this paper is organized as follows. Section 2 briefly summarizes research methods, related work and how the data is collected. Section 3 describes the Disruption Framework that is used as an assessment tool in the study. Section 4 summarizes the timeline of the history of SMS. Section 5 walks through the disruption process and places events caused by SMS into the model. Section 6 summarizes the most important results of the study. Section 7 discusses implications of the results and Section 8 concludes the study by summarizing the key findings and contributions.

## **2 Previous Work and Research Methods**

Historical data related to SMS was collected using literature review and gathering statistics from publicly available sources. Furthermore, historical industry conditions were discussed in semi-structured interviews with industry specialists.

This study mainly relies on Makkonen (2015) and Trosby et al. (2010). The statistics are collected from Google (2016), IEEE (2016), Edita (2016) and Ficora (2016-a).

### **2.1 Previous Work**

There are several authors, such as Makkonen (2015) and Trosby et al. (2010), who have written about the history of SMS. All of these publications together depict quite an accurate portrayal of how SMS was born and how it was developed. Certainly, there are some inaccuracies in the history, mainly due to a lack of contemporary researches during past times but those imprecisions are not found to be critical.

Hong et al. (2008) presents results of consumer behaviour with regard to mobile services. Many consumers use SMS service for building social connections and specifically younger generations tend to build and strengthen group relations using mobile messaging services. This study combines this observation with the diffusion model.

### **2.2 Research Methods**

Mobile services and specifically SMS, is a studied field. As Figure 3-a point out, there are hundreds of different scientific papers published regarding the subject. This study builds on those previous results.

The actual disruption modelling is carried out by using the Disruption Framework (Kilkki et al., 2017). This theory is described more thoroughly in Section 3.

### 2.3 Expert interviews

During the research industry experts were interviewed to gain a deeper insight into the industry conditions that were present when SMS technologies and applications were developed. All interviews had a duration of approximately two hours.

All interviewed persons worked in SMS service development positions, and all of them were employed in these positions when SMS services began to emerge. These individuals represent different layers in the disruption model.

Interviews were carried out using the semi-structured model. The interview transcripts were codified and recognized events were chronically placed into a list. These events are depicted in Figure 5-a and 5-b.

Table 1 contains a list of experts that were interviewed for the study. Names of the interviewed persons, interviewer and interview date are located in the References section.

**Table 1.** Background information of the interviewed persons

Job title	Years of industry experience	Location of interview	The layer in the disruption model
Communications network specialist	28	Helsinki, Finland	Industry / Regulator
Head of Ecosystems Research	35	Espoo, Finland	Science / R&D / Firm
Head of Business Line	27	Helsinki, Finland	Science / R&D / Firm

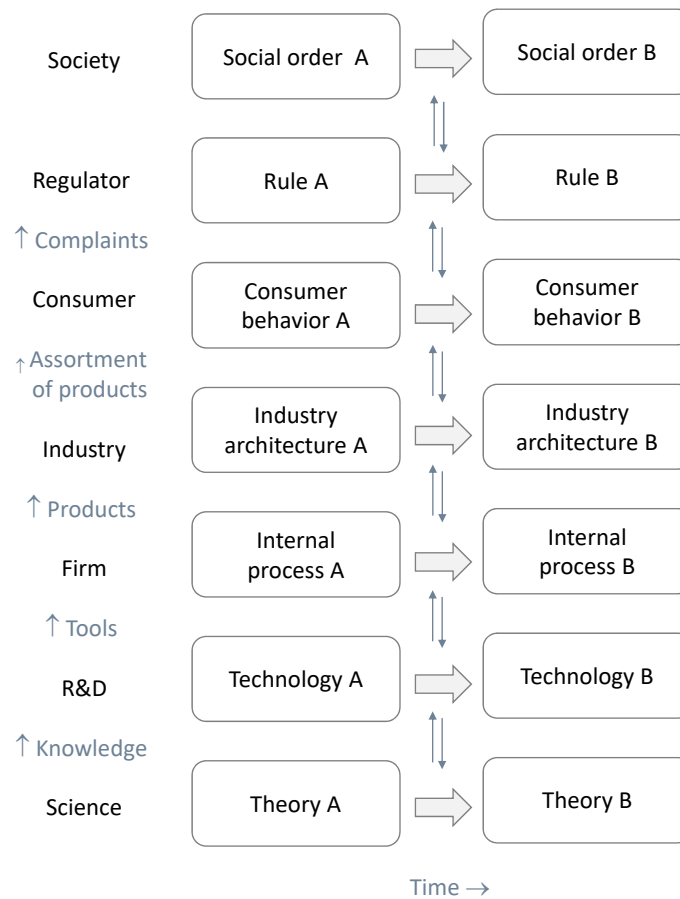
## 3 Disruption Framework

The theory of disruptive innovation was presented by Christensen (1997). Since then, the term disruption has been taken into use in various contexts - sometimes too loosely. There have been several efforts to clarify what disruptions actually are and how they emerge (Markides, 2006; Schmidt et al., 2008; Ritala et al. 2016).

A process and agent-based view could be taken to gain better understanding of a disruption. Kilkki et al. (2017) presents the Disruption Framework which brings structure to the disruption process. The core essence of the framework is the idea that a disruption is an event seen by the agent in an ecosystem. This agent-based view conveniently omits entire ecosystem wide change momentum. Instead, it allows for usage of the term disruption in a small and easily manageable context. The framework also defines relationships between different innovation sources. Kilkki et al. (2017) defines a disruption as,

*An agent is disrupted when the agent has to redesign its strategy in order to survive a change in the environment. From the perspective of a system, disruption is an event in which a substantial share of agents belonging to the system are disrupted.*

The disruption framework model, as seen in Figure 1, divides the disruption process into seven layers of stakeholders. Each layer has a causal relationship with neighbouring layers. For instance, theories have previously emerged from fields of science. Gradually, those theories develop and, using this novel knowledge, new technologies are invented in corporations' and universities' research and development (R&D) units. Those technologies are tools for firm level internal processes that eventually may realize in an assortment of applications in the industry. Due to these new revolutionary products, the behaviour of consumers can change. These behavioural changes may realize as complaints to the market regulator, which sets rules to fix causes behind complaints. Furthermore, a disruptive technology may eventually have an impact on social order. The causal process can go both ways in the model. For instance, consumer behavioural changes may change industry architectures and push for change further in the process.



**Fig. 1.** The Disruption Framework (after Kilkki et al., 2017)

As referred to earlier, the disruption is defined as “...an agent is disrupted when the agent has to redesign its strategy in order to survive...”. The disruption framework

also proposes a formal way to model those strategies made by an agent. As seen in Figure 2, there are several courses of actions that can be taken. In case A, an agent can expand its operations to an alternative industry thereby leveraging innovation made on the other industry. It is also common that incumbents of the target industry (agent C) try to offer more advanced and costly products to maintain industry position. In case B, an agent can enter an alternative industry with a low-end feature set offering a more cost efficient way than competitors, causing others to flee the market (the agent D). It is also possible that a new agent enters the market with an innovation (the agent E).

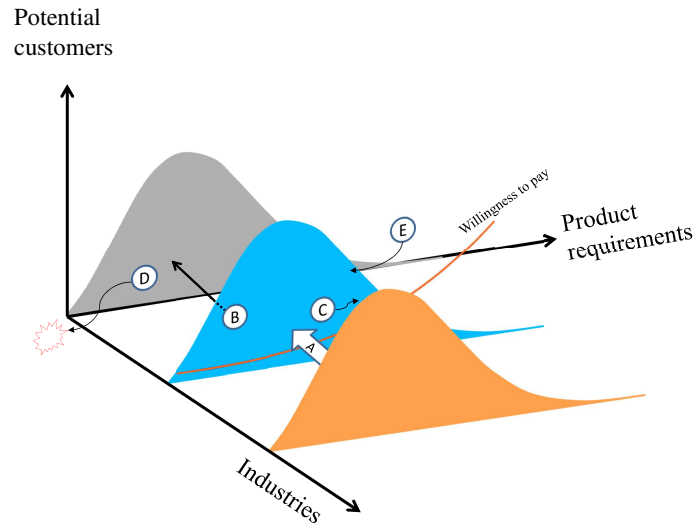
Since the Disruption Framework model is quite easy to apply, it is natural to assume the concept is easy to master. From a technical standpoint, the model is simple, however, it is conceptually strong. It combines parts from social sciences using Agent-based modelling (ABM) (Bonabeau, 2002) to understand how individual agents respond to signals. It utilizes diffusion theory (Rogers, 2003) to understand dynamics between agents. It separates product innovations and new to the market innovations from technological innovations as did Markides (2006).

Before we discuss more about the results of how the disruption framework is applied, let us briefly summarize the history of our chosen case study topic, the SMS.

#### **4 A Brief History of SMS**

The telecommunications industry has grown from being a non-existent entity to becoming a vital element of global businesses in just 200 years. During the early 20th century, technologies matured and commoditized so that communication solutions were achievable by consumers in the Western world. However, before digitalization and global standards, wide scale mobile communication was not feasible for most consumers due to price constraints.

In the 1970s and 1980s, the communications industry was primarily based on national monopoly operators which typically also had a regulatory authority role. Furthermore, in some countries, there were state owned network equipment manufacturers, such as Televa in Finland (Huusko, 2009) and Ellemtel in Sweden (Telia, 2017, pp.7). In European countries, communications specifications and standardization was driven by national governments in CEPT (Trosby, 2010).



**Fig 2.** Model of disruption transition between industries (after Kilkki et al., 2017)

In the mid-1980s, the communications market began the process of transforming into a more open and international mode. In Europe, the governments of France, the United Kingdom, Italy and West Germany agreed to co-operate in the arena of communications development (Makkonen, 2015). CEPT made a decision to plan for European wide mobile communication standards (Trosby, 2010). At this time, government driven development also began to decline.

The service that we nowadays refer to as an SMS was not the first mobile messaging technology. Previously, Data and Messaging Service (DMS) technology allowed for the transfer of messages using a signalling channel in Nordic Mobile Telephone (NMT) service networks. However, deployments were rare. Polish, Russia and Bulgarian NMT networks offered the service. However, a limiting factor of the adoption was the lack of a handset feature to send actual messages. Consequently, a separate device was required to use the service. This existing knowledge and competencies were leveraged when GSM standardization was instituted.

The standardization role of CEPT was transferred to ETSI in 1987. While CEPT only accepted governments as members, ETSI was open also for network equipment manufacturers and operators. ETSI's GSM standardization initially focused on voice communications. The SMS specification was also released in phase 1 but it was defined as an auxiliary value added feature, i.e. it was perceived as unimportant. (Ali-Vehmas, 2016)

Balston (1989a) expresses the industry conditions and environment quite well in his discussion regarding the future of the GSM. "The GSM Committee (sic) has adopted a pragmatic attitude towards its task. It is clearly a partnership between operators and industry which is succeeding, or perhaps indeed because of, deregulation and the competitive pressures being introduced both in the PTTs and their industrial base."

Similar to NMT, the first GSM handsets did not contain the features necessary to send

SMSs. In roughly 1994, some handset manufacturers finally began to include two-way SMS features in their phones. The SMS concept was introduced to consumers as a handset feature rather than as a network service. Since then, SMS technologies have spread into a vast number of different applications. Today, it is not just individuals who use it for everyday communications. In fact, SMS technology has enabled totally new ecosystems and industries to emerge.

Historically, there are two distinctive paths in the evolution of SMS services. First, people oriented applications are designed to be interactive between humans and are used by a handset. Second, industrial oriented applications are the basis for M2M type use cases. In the following sections, we discuss how SMS fits into the general Disruption Framework model.

## 5 Disruption Framework Fit

As discussed in Section 3, the Disruption framework outlines a process that might lead to an event where an agent gets disrupted. In this section, we walk through the process and place events caused by SMS into the model.

### 5.1 Theories and Technologies

Short messaging, as a concept, was discovered in the late 1980s by scholars. For instance, Balston (1989b) discusses the impacts of customer mobility and observes that SMS can be used for sending messages to a user handset. There are several papers after that published on the subject. For example, searches of Google Scholar and IEEE xplore uncovered a total of 155 papers mentioning SMS that were published between the years 1989 and 1997.

Several different stakeholders became interested in SMS during its first decade. From those 155 papers, universities published 38%, network service providers 16%, network equipment manufacturers 15%, other corporations 15%, different research institutes 9% and consulting companies 7%. The driving force behind SMS technology was standardisation administrations, such as national regulators and operators. Those entities were also the stakeholders that published the earliest papers. Hence, this indicates that the disruption process might have started from the industry architectural level and then progressed downwards to the organizational, technological and theoretical levels.

The yearly peak publication rate was achieved in 2010 which is relative late. There are a couple explanations for this delay. In early years, scholars' interest was more on the theoretical, core technological side and only on the telecommunications industry. Later, the focus shifted to numerous applications of SMS technology and interest diverged into several different industries. The time-series for the published papers can be seen in Figure 3-a.

## 5.2 Firm level internal processes

GSM technology was initially specified in Europe for European operators in the late 1980s. At that time, elsewhere in the world, operators were using proprietary mobile messaging solutions, thus, a customer of one operator could not communicate with a customer of another operator. GSM standardization resolved this limitation. Hence, the GSM based SMS service was benefited due to network externalities, i.e., standardization of the GSM and SMS technologies brought more value to a customer and adoption of GSM technology also accelerated also adoption of SMS services.

Although technologies are typically patented by their inventors, SMS based patents are seen as unimportant to the speed of SMS deployments. However, in the Google Patents archive, at the time of this study there are more than a hundred thousand patents that are somehow related to Short Message Service. Patents represent a firm level internal process to protect inventions before those creations are presented to the industry. While these patented features might generate some revenue for a network equipment manufacturer in the form of license royalties, those patents are also creating a barrier for new entrants into the market. Furthermore, there have been several patent related court cases during the last 20 years between handset manufacturers.

The earliest SMS related patent was filed in the 90s. It was during the same timeframe that GSM standards were finalized and a few years after the first SMS related scientific paper was published. The amount of filed patents grew at an accelerated speed until 2007, when the amount of filed patents stabilized to a yearly rate of 10,000. There are some indications that patents per year have started to decline, i.e. firms are generating less protectable innovations than they were earlier. A time-series of filed patents per year can be seen in Figure 3-b.

During the early years of SMS services, network providers had several different scenarios for SMS products and charging models. Initially, some providers considered SMS to be a value added service that would be a separately chargeable service. Furthermore, network service providers' roaming charging and billing capabilities were limited, thus, some users were able to send and receive messages without paying. However, by the end of the 90s, the SMS service model reached a dominant design phase and a pay-per-use model was established in most countries. Nevertheless, there are some exceptions, such as Indonesian' operators, who use flat-fee pricing.

## 5.3 Industry

Standardization can be seen as an industry level method to introduce new interoperable services to the industry. When standards are defined, the era of fermentation ends, and dominant design for services are established. However, it can be assumed that most standards leave room for implementation level innovations.

The first application for sending SMS messages was delivery of operator service configuration messages to users' handsets. This was introduced in the mid-90s. Later in the 90s several service companies from number of different industries observed that SMS can also be used for carrying user requests to a non-mobile system that provides value-added services (VAS). These services created totally new business



models and enabled companies to offer digital channels for their services. For instance, mobile payment (bus and tram tickets) and mobile banking (small loan requests) are just a few of those business models. Many of these use cases can be seen as low-end disruptions for service companies. Hence, new business models were introduced into existing markets. Nevertheless, from a network service provider's point of view, the same kind of revenue sharing model was deployed that was in voice based service numbers, i.e. from a network service provider's point of view there was no disruption.

Some service companies discovered that they could use SMS to send different types of information and queries to users. For instance, instant customer service surveys (customer satisfaction queries) enabled companies to establish a new pace for development of customer servicing processes; likewise, SMS based one-time-passwords could be used in application authentication processes to reduce the risk of cyber-crime. Machine-to-human communication also enabled new forms of industries to emerge. There are a few new-to-the-world products that were introduced, but mostly these can be seen as a low-end disruption.

In the late 90s, the Finnish regulatory authority introduced SMS service numbers for companies in Finland. These numbers are used in person-to-machine (P2M) and machine-to-person (M2P) services to indicate the type of service. Time-series for those assigned SMS service numbers in Finland can be seen in Figure 3-c. The amount of numbers assigned yearly has remained quite stable over the past 16 years. Growth remains strong and there are no clear signs of a market decline. This same service number model has been applied in some other countries, as well. All previously mentioned use cases are well known by consumer users. However, one could argue that the most revolutionary use of SMS is actually machine-to-machine communication (M2M).

Currently, there are hundreds of different SMS based applications available in the M2M domain. For instance, electric companies have installed mobile connected smart meter devices that enable remote consumption monitoring using SMS technology, thus, they have removed the need for manual reporting and redundant labour. In the oil industry, gas companies monitor tank levels to optimize refills. SMS technology has enabled utility companies to digitalize their firm level internal processes to reduce manual work. The driving force is the desire to improve operational efficiency in those companies that have selected cost-leadership as their primary strategy, as most utility companies have done. In these cases, SMS can be seen as a disruptive innovation. However, it can be argued that companies have not actually changed their entire strategy due to SMS, but rather, have just fine tuned their strategy implementation. Nevertheless, there is a common trend that companies are adapting their digitalization strategies which also covers SMS services.

On the other hand, there are some attempts to replicate the success of SMS. In the mobile market, email was viewed as an alternative technology but operators found the transaction based billing model more attractive, thus, operators advocated Multimedia Messaging Service (MMS) technology instead. However, MMS was unsuccessful in comparison to what was predicted for it and it was unable to disrupt SMS or any other messaging technologies. Consequently, it remained a niche market. There are some indications that the reason for the MMS failure was the service pricing.

#### 5.4 Consumer

From a consumer's view point, at least four different use cases can be recognized that SMS has enabled. The first is person to person communication. In this model, a service user communicates directly with another person using a mobile handset. The person to person communication model has changed consumer behaviour the most so far. All modern handsets contain the SMS feature and it is a significantly used feature. At the end of 2015, there were a total of 7.2 billion mobile subscriptions globally (ITU, 2016). The report of Deloitte (2013) indicates that globally, the daily SMS volume is more than 20 billion messages, which is roughly three messages per subscription.

As Hong et al. (2008) observed, consumer adoption of the service is more rapid when there is social effect involved. From a consumer perspective SMS can be seen as a disruptive innovation because there was no mobile messaging solution available before SMS and introduction enabled people to communicate while on the move. Consequently, the adoption rate of mobile handsets with the SMS feature grew quite rapidly.

The second use-case is messaging between a user and a machine, and the third use-case is vice-versa. As described in Section 5.3, there is abundance of different SMS based services available nowadays. From a user perspective, SMS is a disruptive technology. Actions, for instance visiting a service point or sending traditional snail mail, took a lot of time earlier and can now be carried out within seconds using SMS. These SMS based services have changed consumers' behaviour radically. Anymore, traditional service models are seen as unattractive by consumers and those traditional service providers become disrupted in several industries.

The fourth model is purely machine to machine without any user intervention. The example mentioned in Section 5.3, electricity consumption metering, has also changed consumers' behaviour. Now consumers can monitor their electricity consumption almost in real time and optimize their usage. However, most of these services are such that the user does not know or does not care if the company is using SMS.

#### 5.5 Regulation

It is well known that regulations and legislations are established to fix problems in the market. This is also the case with SMS regulation. During the early phase of SMS, there were some issues that forced regulators to intervene.

For instance, in Finland in the late 90s, several customers accumulated huge bills by ordering SMS based ringtones and other special services without knowing how much the services cost. These issues were created due to an absence of separate service numbering for specially priced services. As a consequence, users were unaware if the service they were utilizing was using standard or special SMS service pricing. Hence, the telecommunication regulator authority decided to introduce SMS service numbers as a solution to overcome these issues that SMS had generated. At the time of this study, there are more than 1,300 individual service numbers in use in Finland. (Rakkolainen, 2016)

However, traditional regulatory actions have not prevented all SMS related problems from occurring (Edita, 2016). For instance, in Finland, there are several court cases where SMS has played some kind of role in the lawsuit. Furthermore, public authorities such as the Finnish consumer ombudsman have published several SMS related policies to steer the market into the right direction. The time-series of those different court cases and policies can be seen in Figure 3-d.

On the other hand, the European Commission (EC) has instituted regulations that lower the roaming charges between countries. These regulations acts have changed the industry architecture in the telecommunications industry within Europe. For instance, regulations regarding roaming on public communication networks prompted national regulators in 2012 to adapt policies that set cost based tariffs between operators (E.C., 2016). After that, the EC set even more stringent roaming tariffs regulations. Tariffs will decrease gradually, and eventually, starting June 2017, sending and receiving an SMS in a roaming network within the EU will cost the same as in the home network. Hence, these regulatory measures disrupt network service providers' SMS market.

## 5.6 Social Order

The top layer in the disruption model, the social layer, represents the entire society's social order. However, dynamics of the social structures are well beyond the scope of this study. Nevertheless, there are some cases where SMS has had some kind of clear role regarding social order.

For instance, some governments use SMS services to announce a state of emergency for citizens. These include such announcements as severe weather condition, terrorist attacks, traffic alerts and gas leaks. Obviously, the reason for these announcements is to keep citizens safe. Furthermore, in some nations, governments restrict citizens' freedom of speech. SMS has enabled these people to communicate more freely, exchange ideas, form social groups, and possibly cause a revolution.

The collected statistics can provide indicators of the timing of different events during the disruption process. Figure 4 illustrates a normalized time-series of the statistics seen in Figure 3. It can be seen that the first item to emerge was scientific publications, the second item was patents, the third item was service numbers and the last item was court decisions. The order is the same as the order of the layers in the disruption framework. However, the order of reached maximums does not follow the same order. The first to decline was patents, the second to decline was service numbers, the third to decline was publications and the last to decline is court decisions.

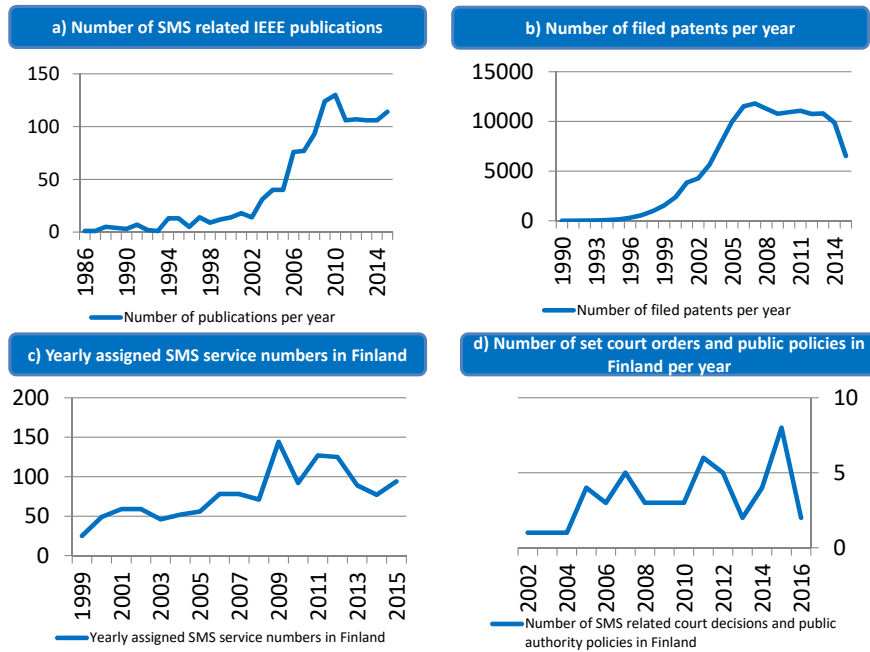


Fig. 3. Statistics related to SMS from different layers of the Disruption Framework

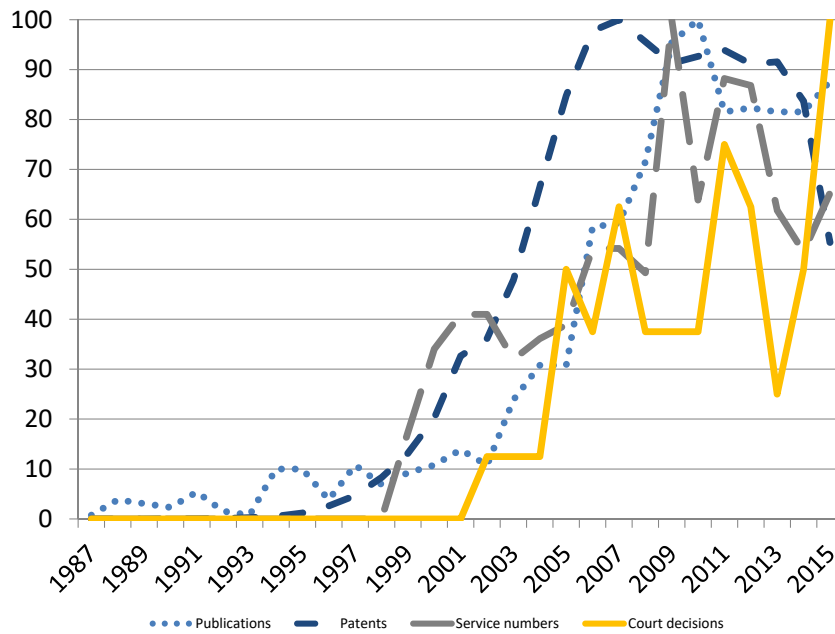


Fig. 4. Normalized time-series of different statistics

## 6 Results

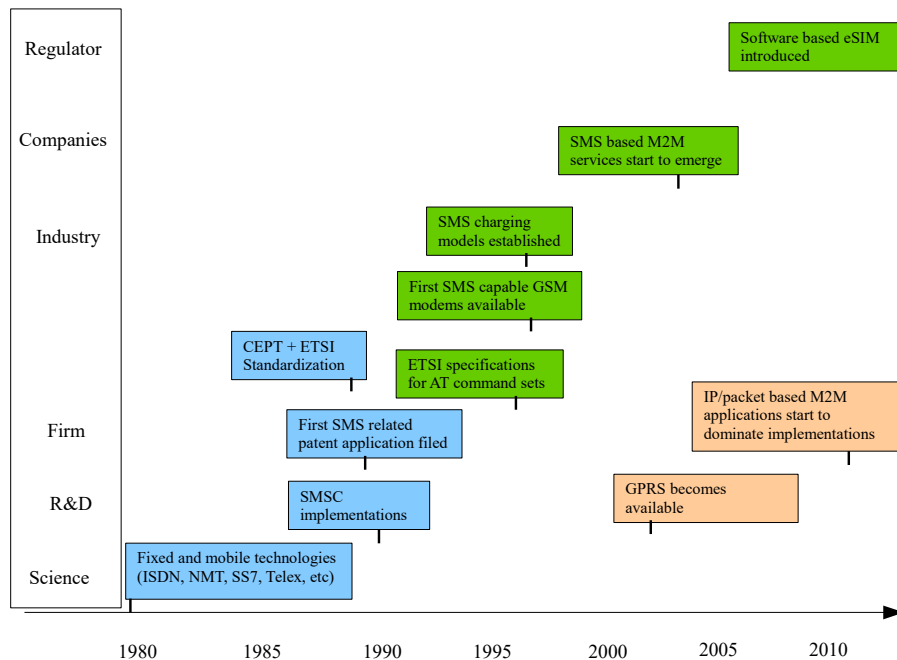
SMS was not the first text messaging service on the market. Telex, fax, etc. (Trosby, 2010) were widely used for decades before SMS. However, those options did not offer mobility. SMS introduced mobility for both senders and receivers. Predecessors required separate devices on both ends, while in SMS a typical mobile handset provides all required functions. Standardization bodies and network equipment manufacturers were able to leverage old knowledge inherited from analogue technologies. In that sense, SMS can be regarded as a technology that disrupted previous messaging services.

Today, completely new industries have been born that leverage SMS, especially in the M2M area. SMS has been a disruptive innovation mostly for consumers, but certainly, it has also been disruptive for service businesses.

Events during the history of SMS can be separated into two distinctive categories: a) Industrial applications related events that created the pathway for M2M type applications. Figure 5-a illustrates that timeline. b) Consumer applications related events created the pathway for those applications that are human interactive type. Figure 5-b illustrates the timeline for these events. Both of these paths began in the early 80s and the pathways started to diverge in the 90s.

However, there are some indications in both of these cases that other emerging technologies have already started to disrupt SMS ecosystem agents. Those replacement services started to emerge in the late 2000s.

The success of SMS has also been the cause of its eventual doom. Some handset vendors have implemented proprietary SMS solutions in their ecosystem, e.g. iMessage in Apple IOS based devices. These Internet based proprietary services are bypassing network service providers' SMS centres and billing systems, thus, users of that ecosystem are able to communicate without extra cost. Furthermore, other proprietary Internet based messaging solutions are disrupting SMS as well: for instance WhatsApp, Facebook and WeChat. These new applications have significantly decreased network service providers' revenues. On the M2M side, IP packet based technologies are replacing SMS based applications on some new implementations.

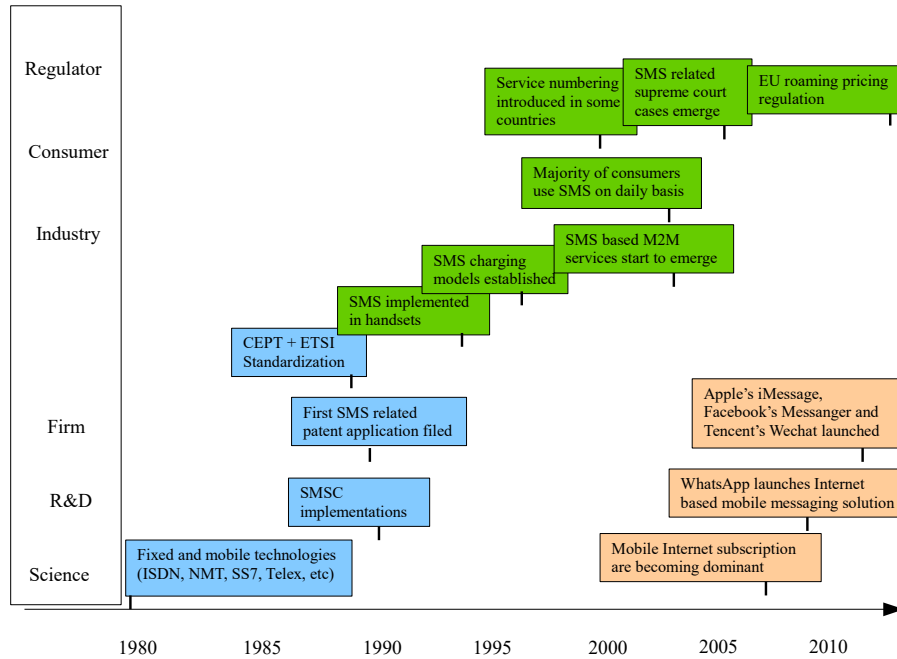


**Fig. 5-a.** Industry applications related events on the timeline on the different layers of the Disruption Framework

Although the presented disruption model does not mandate any rate of adoption for a disruptive event, it can be assumed that only relatively fast changes in the ecosystem can cause such discontinuity that some agent perceives it as disruptive. One way to measure the rate of the change is by using the diffusion model (Rogers, 2003). For instance, Andersson and Hedman (2007) studied diffusion of advanced mobile services, including SMS, in Swedish companies in 2006 and observed that adoption of the SMS service was rather slow. On the other hand, there is a common trend when we compare observations made by Andersson and Hedman (2007) with the statistics seen in Figure 4. Before the mid-2000s the numbers of patents, service numbers, court cases and published papers were relatively low but after the mid-2000s all of these numbers have grown significantly. This indicates that the innovators and early-adopters' phases were timing before the mid-2000s, at least for SMS based services. The majority phase approximately started in 2006.

There are some clear cases where companies have changed their strategies to leverage SMS on an alternative business domain. For instance, SMS is widely used in the marketing industry (event B). At the same time, some traditional marketing firms have been put out of business (event D) because their paper-based advertisement model no longer attracted companies' attention. A second example, mentioned earlier, is Apple's iMessage service. The mobile handset manufacturer entered the SMS arena by capturing all messaging between Apple devices and preventing operators from charging for the traffic (event A). This action forced operators to shift their focus on to more value generating services such as mobile data plans and over-the-top (OTT)

video services (event C). However, there are new entrants in the field (event E). For instance, Google has introduced their global mobile subscription service that includes unlimited SMS service. The illustrative diagram can be seen in Figure 6.



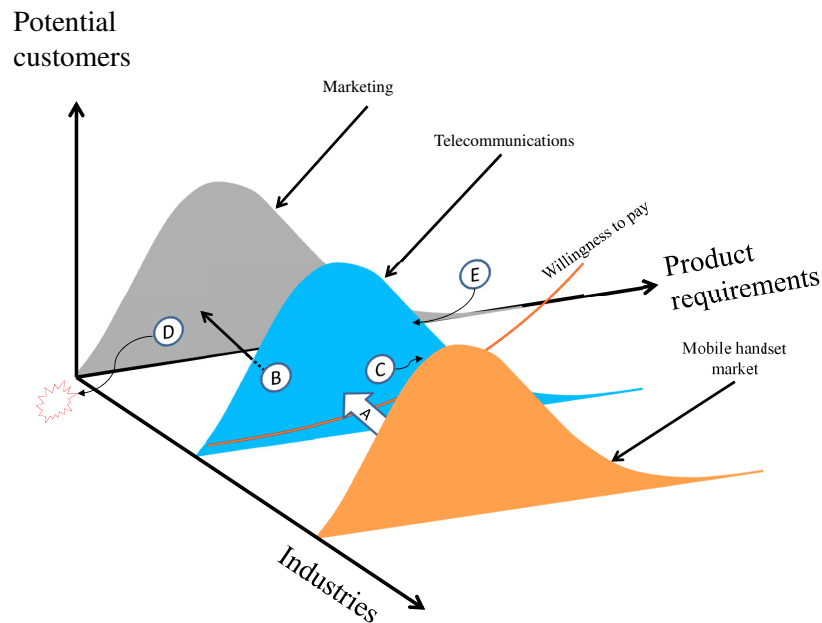
**Fig. 5-b.** Consumer applications related events on the timeline on the different layers of the Disruption Framework

## 7 Discussion

This paper contributes practically and theoretically to modelling of disruptive innovations. Pragmatically, the assessment of SMS using the Disruption Framework reveals the process of how SMS has diffused into the different layers of the ecosystem and how different industry stakeholders have experienced this process. Regarding theories, there are two views. First, SMS can be used as a qualitative indicator that there actually is a real world application that fits into the Disruption Framework theory. The framework was found to be accurate enough to be used for modelling a dynamic process of innovation diffusion and then to identify events that are either low-end disruptions or new-to-the-world innovation based disruptions. Second, by defining the term disruption from an agent-based view, this theory builds a foundation for more advanced ecosystem modelling.

One aspect of technology disruptiveness is whether or not it is a competence-enhancing or competence-destroying (Anderson, 1990) innovation. In the case of SMS, there are indications that the base core technology behind SMS, the GSM, is actually competence-destroying. GSM standards are based on digital technologies

rather than analog technologies. Control-plane programmability allows for introducing new features to the network by upgrading standards, mobile core and handset software. Palmberg and Martikainen (2005) discuss why Nokia, as a network equipment manufacturer, was able to succeed. They also observed that most of the competencies that were required in NMT need to be replaced in GSM technologies. Hence, this indicates that SMS was seen, together with GSM, as a disruptive technology for network equipment manufacturers.



**Fig 6.** Technological diffusion from an industry to another (after Kilkki et al., 2017)

In conclusion, the disruption framework is useful when applied to the ecosystem of some wider phenomena. Examples presented in this paper are just indications of compatibility to the framework. The model can be used for modelling the process that may lead to a disruption. The model can also be used to understand temporal dimension of the technology diffusion within an ecosystem.

This study also contains some limitations. This study was carried out in Finland and all interviewed persons were Finnish although they all have international industry expertise. One way to improve the scope of the study would be to include interviewees from several different regions. Furthermore, there were only three industry experts interviewed to support the literature study. It is obvious that if more persons were interviewed it is likely that some other viewpoints would be addressed.

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### Interviews.

Timo Ali-Vehmas, Nokia, Helsinki

Interviewed on 19.8.2016 by J. Lähteenmäki

Petri Pöyhönen, Nokia, Helsinki

Interviewed on 6.9.2016 by J. Lähteenmäki

Jukka Rakkolainen, Finnish communications and regulatory authority, Helsinki

Interviewed on 1.9.2016 by J. Lähteenmäki

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