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KNOWLEDGE AND TECHNOLOGY AS FLUIDS – EXAMINING KNOWLEDGE AND TECHNOLOGY PRACTICES IN THE TELECOMMUNICATIONS INDUSTRY

John Alphonse and Ole Hanseth

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Information Systems group
University of Oslo
Gaustadalléen 23
P.O.Box 1080 Blindern
N-0316 Oslo
Norway
http://www.ifi.uio.no/forskning/grupper/is/

Knowledge and Technology as Fluids – Examining Knowledge and Technology Practices in the Telecommunications Industry

John Alphonse
Dept. of informatics
University of Oslo
P.O. Box 1080 Blindern
0316 Oslo
Norway
<johna@ifi.uio.no>
+47 2285 2410 (phone)
+47 2285 2401 (fax)

Ole Hanseth
Dept. of informatics
University of Oslo
P.O. Box 1080 Blindern
0316 Oslo
Norway
<oleha@ifi.uio.no>
+47 2285 2410 (phone)
+47 2285 2401 (fax)

Abstract:
In knowledge and technology intensive industries such as the telecommunications industry, "practices" tend to be a mixture of knowledge and technology. Research however has been largely treating these two entities separately, addressing one while black boxing the other. It is however this mixture that represents reality. We examine two practices which were considered to be best practices for a telecommunications company. The practices are both knowledge and technology intensive but to varying degrees of each. The first is a brand segmentation model targeting the youth. The second is a set of guidelines for using a speech coding algorithm within the GSM standard. We use a brief review of how knowledge and technology have been conceptualized to show how the two can be considered as equals. This is a departure from particularly Knowledge Management which largely views technology only as a tool. We use the development within the Actor-network Theory literature in moving from 'networks' to 'fluids' to argue the case for conceptualizing knowledge, technology and the practices as fluids. Fluids consist of mixtures and have unclear boundaries, multiple identities, continuity, and robustness. The fluid concept fits the knowledge and technology intensive practices we describe as does its knowledge and technology components. By virtue of its properties, the fluid concept can add to our understanding of how fluid practices can be managed. Their boundaries and composition are dynamic which require dynamic cross-functional approaches. They are more robust when their multiple identities are aligned and less robust when their identities are in conflict. Their movement (or transfer) from one context to another is determined by the extent to which ownership, control and influence is able to move as well.

Keywords: knowledge, technology, fluids, telecom industry, best practices

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1. Introduction

There is a general acknowledgement that 'knowledge' has been difficult to define (Schultz & Leidner, 2002; Davenport & Prusack, 1998) and that its understanding is still at an infant stage despite the numerous amount of literature that has been published on the subject (Griffith, Sawyer & Neale, 2003). 'Technology' has been experiencing a similar fate, with disagreements over its definition and role in organizations (Orlikowski, 1992; Orlikowski & Iacono, 2001). Both knowledge and technology are however vital to organizations especially in industries such as the telecommunications industry that are both knowledge and technology intensive. In such industries it is the combination of knowledge and technology that is of most interest. For if a technology is easily understood and generally available, they give no competitive advantage as any firm can imitate and use them (Davenport & Prusack, 1998). The advantage to the firm could then be in terms of knowledge on the use of that technology that could give it some advantage over its competitors. Similarly, if some knowledge becomes easily understood and generally available, it could be a technology around it that was difficult to understand and imitate that could give a firm an advantage (Kogut & Zander, 2003). Thus it is possible that knowledge and technology are not just embedded in the practices of knowledge and technology intensive industries because of the nature of the practices, knowledge and technology; but also because it is in the strategic interest of the companies to combine them.

In this paper we shall examine two such knowledge and technology intensive practices from the Norwegian mobile telecommunications company Telenor. They were considered "best practices" by the company and we shall take them to be good examples of practices in general for the company; and shall refer to them as practices. We are aware that the term 'practices' can have a number of meanings but our choice is to continue for the time being to describe them as they were generally described by the company. It is part of the intention of this paper to explore a more appropriate conceptual description of such phenomenon which would make any attempt to derive another name at this stage counterproductive. The practices are multifaceted complex phenomenon with a proven record for generating revenue and providing competitive advantage. They were selected because of their importance to the organisation and also because they represented practices which were considered both knowledge and technology intensive but to varying degrees. The first which is rooted in Marketing, is a brand segmentation model called djuice which targets the youth segment. This practice from the outside appeared to be relatively more knowledge intensive than technology intensive. The second, rooted in Network Planning, is a set of guidelines for using a feature known as half-rate within the GSM standard. Half-rate increases the network capacity by using a speech coding algorithm that reduces the effective bit-rate for each calling party. This practice appeared to be relatively more technology intensive than knowledge intensive. We will thus two practices that are relatively places on either side of the knowledge and technology intensive spectrums.

This research is significant for a number of reasons. The Telecom Industry in 2003 was worth US$ 1 426 billion (ITU, 2006). The global telecom companies have been consolidating and there is significant interest within these companies to industrialized

practices and recreate them in their different subsidiaries around the world. The knowledge and technology gaps between these globally distributed companies have also narrowed and such best practices are emerging from developed countries as much as from developing countries. As an indication of this one of the practices we shall be examining, djuice originated from Norway and Sweden while the other, the half-rate guidelines, from Bangladesh. The practices these telecom companies are involved in are significant and relevant to these telecommunication companies in developed and developing countries. djuice was brought to Hungary, Ukraine, Bangladesh and Pakistan; and half-rate to Ukraine, Malaysia and Norway. The mobile phone industry is in itself interesting. It plays a significant role in everyday life with 1.76 billion mobile phone subscribers worldwide in 2004 (ITU, 2004). The practices we are studying are typical practices in the telecom industry and involve both knowledge and technology. The tendency in research however has been to discuss knowledge and technology separately, and generally to 'black-box' one when discussing the other. From two reviews made of the Knowledge Management literature by Schultz & Leidner (2002) and Alavi & Leidner (2001), we see that when technology is discussed, it is to discuss how technology is or can be used to manage knowledge. Technology is viewed as a tool. There is no discussion of knowledge and technology as similar, parallel or inter-related artefacts. The more common discussion places knowledge in relation to information and data, and to implicate technology in terms of what can be codified. Research on technology in a multifaceted or 'ensemble' view has also been under researched (Orlikowski, 2001). However, it is these practices which are a combination of knowledge and technology that represent reality for telecom companies (in an economically significant industry providing services that affect a vast majority of people in their everyday lives). We also feel that this paper is especially significant in Information Systems as it combines two of its core research areas of knowledge and technology within another significant research area, the telecommunications industry.

That there does not exist a stronger connection between knowledge and technology as similar concepts is in fact surprising. Layton (1974) reflected the view of the scientific community at that time that technology was knowledge. In a review of the use of the term 'Technology' versus 'Science' in America since the 1930's, Wise (1985) draws the conclusion that "treating science and technology as separate spheres of knowledge, both man-made, appears to fit the historical record better than treating science as revealed knowledge and technology as a collection of artefacts" (pp 244). The position he takes and supports sees "the knowledge behind the tools, not the tools, as the essence of technology" (pp 230).

Even if they are dealt with separately, how has knowledge and technology been conceptualized? We will describe how knowledge and technology have been described particularly in the IS literature by relying on two major reviews. In one, Schultz and Leidner (2002) reviewed six IS journals from 1990 to 2000 that have addressed the concept of 'knowledge'. In the other, Orlikowski and Iacono reviewed 188 articles in ISR (Information Systems Research) from 1990 to 1999 to see how 'technology' has been addressed. This will take us to a discussion of ANT which has as one of its central themes addressing human and non-human (in particular technology) within the same plane. This

will lead us to the concept of 'fluids' which has been used in social studies of science to describe the disease anaemia (Mol and Law, 1994) and a bush pump (de Laet and Mol, 2000). Our theoretical proposition shall be that to offer the fluid concept as a means to illustrate knowledge, technology and the interaction between knowledge and technology in practices that contain both.

We conclude this Introduction by clarifying our position on two matters. Firstly with regards to the terms information technology and technology. In Orlikowski and Iacono (2001), it does appear that information technology and technology has been addressed as a single concept. Although convergence is not always a straightforward matter (Lind and Zmud, 1991) and convergence of technologies, research of those technologies, development of those technologies and user perception of those technologies can all be different; we will take the position that the borders of information technology vis-à-vis other technologies have become blurred and for our purpose 'Information Technology (IT)' and 'Information and Communication Technology (ICT)' is synonymous with 'Technology'.

Secondly, we will see shortly that the conceptualizations of knowledge and technology make extended use of metaphors. The fluid concept we offer could also be seen easily as a metaphor. It is not within the scope of this paper to discuss the difference between metaphors, models, concepts and theories; however we would like to briefly establish metaphors as a useful if not necessary conceptualization of complex phenomenon. From Lakeoff (1992), the locus of metaphors is not language but thought; and metaphors are the main mechanism through which we understand abstract concepts and complex phenomenon. Through mappings across conceptual domains, metaphors aid our understanding of relative abstract or unstructured subject matter in terms of more structured subject matter. From Brown (1976), metaphors can be considered models which can lead to theories and yet theories themselves could also be described as metaphoric. Metaphors can also be seen as experiments allowing for abstract and complex phenomenon to be tested within more manageable contexts. Thus even if the later discussion could be labelled a discussion of metaphors, it is still nevertheless a useful endeavour if not a necessary passage to approach our complex subjects of knowledge and technology.

2. Knowledge, Technology and Fluids

2.1 Knowledge

We do a brief review here of how organizational knowledge has been conceptualized in some of the literature. Our point is to show that there a number of views to knowledge that among others see it in terms of its nature, what it can do and where it is found. The last categorization is in fact our starting point where early research on organizational knowledge can be found labelled as organization learning and "are first identified and are distinguished by the assumptions they make about the location of knowledge, i.e. in bodies, routines, brains, dialogue or symbols" (Blackler 1995, pp. 1022). To briefly describe some of the types, classification and metaphors of knowledge that has been

described in previous studies; Blackler identifies five images of knowledge: embrained, embodied, encultured, embedded and encoded.

Nonaka et al (2001) classified knowledge resources that are involved in value creation for the firm as knowledge assets (shown in Table 1). Knowledge assets are considered dynamic and constantly evolving. New knowledge assets can be created from old ones.

Experiential knowledge assets (tacit)	Skills and know-how of individuals Care, love, trust and security Energy, passion and tension
Conceptual knowledge assets (explicit)	Product concepts Design Brand equity
Routine Knowledge assets (tacit)	Know-how in daily operations Organizational routines Organizational culture
Systemic Knowledge assets (explicit)	Documents, specifications, manuals Database Patents and licences

Table 1 Categories of knowledge assets, Source: Nonaka et al (2001)

It is worth repeating from Table 1 that routines are listed as tacit knowledge. Brown and Duguid (2001) go further in using the term 'routinization' where unpredictable events are reduced to practices that fit organizational methods and capabilities. The authors also distinguish between knowing-what (declarative knowledge) and knowing-how (dispositional knowledge). They use the word ensemble to describe how knowledge often involves an ensemble of people with different know-how to fulfil a practice.

In the definition of knowledge from Davenport & Prusack (1998), "knowledge is a fluid mix of framed experience, values and contextual information, and expert insights that provides a framework for evaluating and incorporating new experiences and information. In originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices and norms" (pp. 5).

Schultz and Leidner (2002) reviewed 94 research papers within six IS journals that addressed the concerns of organizational knowledge. The authors adopt the approach of classifying the papers under four discourses: normative, interpretive, critical and dialogic. The vast majority of the papers (91) are classified under the normative and interpretive discourses. Under each discourse, the knowledge metaphor is discussed, where in the normative discourse it is categorised as an object and/or assets in two basic forms. In one, where it can be stored and manipulated independently of the human source and the other, where it cannot be extracted from its human source. In the interpretive discourse knowledge is generally socially constructed and embedded in practices. The metaphors listed of how knowledge can be conceptualized are summarized in Table 2.

Knowledge Classifications/Types	Metaphors
Episodic and Semantic	Memory, Information, Stock
Declarative (know-what)	Rules, Chunks
Procedural (know-how)	Explanations, Competence, Job Experience, Familiarity
Conceptual (know-why)	Expertise,
Problem- solving	Problem-solution sets
Situated Practice	Organizational Mind
Culture	Organizational Mind
Learning	
Neutral Object/Resource	Commodity
Type of Knowledge; System for Correction and Control	Discipline
Power-Knowledge	Rendering phenomenon visible, thinkable, calculable and amendable to intervention

Table 2 Metaphors of Knowledge, Source: Schultz & Leidner (2002)

Alavi and Leidner (2001) review knowledge-centred literature and summarize the different perspective of knowledge under: knowledge vis-à-vis data and information; sate of mind; object; process; access to information; and capability. In terms of knowledge types, they identify: tacit, explicit, individual, social, declarative, procedural, causal, conditional, relational, and pragmatic. The authors describe the tacit-explicit distinction as being the most widely cited knowledge classification.

We end this brief review by concluding that all the classifications of knowledge here give ample credence to our describing the practices we shall examine later as knowledge. This shall be made clear when we describe the practices.

2.2 Technology

Layton (1974) makes the link between technology and knowledge that goes back to Aristotle and Plato, and that the separation of knowledge and technology is recent, artificial and self-contradictory in devoiding technology a thought component. Layton puts forward the view of "technology as a spectrum with ideas at one end and techniques and things at the other, with design as a middle term" (pp. 37). Wise (1985) also builds the case for technology as knowledge. He argues against technology relying on science for knowledge with how technology builds its own knowledge bases and that new technology develops out of technology itself. As Wise also implies, what may have been established is knowledge as a metaphor for technology. For our purpose these help legitimize our position on seeing knowledge and technology as equals.

Orlikowski (1992) describes the duality of technology which she sees as a way of categorizing previous views of technology. Technology is either an object or a product of human action. The difference between these two conceptualizations appears as a discontinuity in time and space, where developers of the technology see it as something that is constructed and the users, something which is used. Orlikowski however argues that this discontinuity is created by differences in the areas researchers have focused on. Her position is that these areas are strongly connected and that technology can be understood as "continually socially and physically constructed" through those that affect technology as well as those who are affected by it. Orlikowski uses the term 'interpretive flexibility' as means of conceptualizing the degree of those affects, an attribute of human-technology relationships.

Orlikowski and Iacono (2001) reviewed the "technology" artefact in 188 articles published in Information Systems Research (ISR) from 1990 to 1999. The conceptualizations of technology were categorised under five themes: Tool, Proxy, Ensemble, Computational and Nominal. The themes and sub-themes are shown in Table 3.

Theme	Conceptualization of Technology
Tool	Labour Substitution Tool; Productivity Tool; Information Processing Tool; Social Relations Tool
Proxy	Perception; Diffusion; Capital
Ensemble	Development Project; Production Network; Embedded System; Structure
Computational	Algorithm; Model;
Nominal	Absent (incidental or in the background)

Table 3 How Technology has been viewed and engaged in IS research, Source: Orlikowski and Iacono (2001)

Orlikowski and Iacono (2001) find that the majority of the articles (about 70%) have taken the Nominal, Computational and Tool views of technology where technology has been either absent, black-boxed or abstracted. With the IS phenomena becoming increasingly emergent, the authors expressed a need for more research on the ensemble view. In the ensemble view, the more technical aspects of the technology are seen as an element of a total package. The authors use Latour's (from Latour (1997)) metaphor of an "assembly of forces" where any given technology is made up numerous dynamics that sustain its development and use. The view would be "essential if the IS field is to make important contributions to the understanding of a world become increasingly interdependent with ubiquitous, emergent and dynamic technologies" (pp. 130).

This is exactly what we shall be doing in examining djuice and half-rate which can be easily described within the ensemble view of technology. We wish however to end this discussion on technology by drawing attention to some similarities between the conceptualizations of technology and knowledge. Firstly and in general, just as with knowledge, the conceptualizations of technology have also been concerned with what technology is as much as where technology is. Secondly, whether technology is an object or a product of human action as categorized by Orlikowski (1992) could be used to regroup the knowledge classifications in Table 1 from Nonaka et al (2001). Thirdly, to

some extent, Table 2 of knowledge metaphors from Schultz and Leidner (2002) could categorized under the headings of Tool, Proxy, Ensemble and Computational of technology from Table 3 by Orlikowski and Iacono (2001). However, fourthly and most importantly, Brown and Duguid (2001) and Davenport and Prusack (1998) describe knowledge as an ensemble and fluid mix which fits with Orlikowski and Iacano's (2001) ensemble view of technology which also fits with the practices we shall examine. With this in mind we now turn our focus to selecting a theoretical lens which can be used to examine this 'ensemble'.

2.3 Fluids

Our theoretical framework of a fluid is taken from the so-called Science and Technology Studies (STS) field – indeed the academic field where both knowledge and technology are in focus – in particular more recent developments within Actor-Network Theory, the so-called "after ANT" (Hassard and Law 1999) "movement" and the concept of "fluids" as presented by Mol and Law (1994) in their study of anaemia as a social phenomenon in a fluid space, De Laet and Mol's (2000) study of a Zimbabwean Bush Pump (a water pump) as a fluid object.

At the center of STS studies has been, first, the dense web of relations between the scientific and the non-scientific (i.e. political, social, etc.) in the construction of scientific facts and theories, and, second, the similar web of relations between the technological and the non-technological in the realm of technology (or more generally: between the humans and the non-humans in both areas). Both scientific facts and technologies have been described as heterogeneous networks. Bruno Latour (1986) called what we normally have seen as objective and scientific (i.e. universal and context free) facts and working technologies "immutable mobiles" – they are "objects" that move around in time and space, but they stay the same. According to Latour, the making of such an immutable mobile is quite an achievement. And it is not only the object in itself that needs to be created. Its context also needs to be constructed in specific ways. For instance, to make a computer system work, we need electricity, buildings and furniture, and an organization of people with various competences and roles, etc. The "immutable mobile" in itself is then portrayed as a heterogeneous network, but in addition to be both immutable and mobile another heterogeneous network need to be in place.

In the "after ANT" movement it is argued that now the world has become more complex, and that most "objects" (knowledge, technology, practices, etc.) need to mutable to be mobile. They need to be "mutable mobiles," which means that they are better conceptualized as fluids than as networks.

In Mol & Law (1994) the concept of fluids is introduced through an empirical study of anaemia in Africa and the Netherlands. The fluid concept is seen from a topological point of view, as a space, and in particular in contrast to a region and a network. The authors engage an entity by the space it occupies which in this case (of anaemia) is argued to best described as fluid. The fluid space has the characteristics of having firstly, no clear boundaries. There is no clear starting point or ending point (as would be the case of a

region) or point of passage (as would be the case of the relations in a network). “In a fluid space it’s not possible to determine identities nice and neatly, once and for all. Or to distinguish inside from outside, this place from somewhere else. Similarity and difference aren’t like identity and non-identity. They come, as it were, in varying shades and colours. They go together.” (p. 660). Secondly, a fluid is a mixture and made up of heterogeneous entities. These entities may or may not be fluid themselves. It may not be possible to separate the individual components of a fluid or to mix them. Thirdly, fluids are robust. They can be shaped and re-shaped and are continuous even within such transformations.

de Laet and Mol (2000) describe technology (in the form of the Zimbabwe Bush Pump) as “fluid”. A fluid has six characteristics some of which are closely related. A fluid has: no clear boundaries; multiple identities; mixtures; robustness; continuity; and dissolving ownership. We will consider each of these characteristics. Possibly the most important and defining characteristic is that the boundaries of a fluid technology are not clear. Boundaries are defined by all that is needed to make the technology work. This leads to the second and closely related characteristic of multiple identities. There are many answers to asking the question “What is the Zimbabwe Bush Pump”. It is a water pumping device, a hydraulic system, a sanitation device, a health provider, a community builder and a nation builder among others. Each identity has its own boundaries that are defined by what is needed for the technology to work as that identity. The boundaries are different for each identity and change over time. The identities themselves are not stable and change over time and in different contexts. Some identities may be emergent resulting from collective use of the technology reaching a certain level, e.g. nation building and water infrastructure. Some identities of the technology are defined by elements in its environment and not by its own elements. As a consequence of the multiple identities, the fluid can be said to be robust as it is successful or unsuccessful based on its which of its identities is working and not working. It is not clear when it stops acting, achieves its aims and when it fails and falters. Although in the case of the Bush Pump, some components could be substituted or done without, it is not that kind of robustness which is conveyed. Lots of things can make the pump stop working but because of the multiple identities the robustness comes from its multiple purposes and there being no single weak link that can make all the identities come apart. The strongest link (or General of the Army) may also dissolve and not be obvious. The fluid is also continuous. It may have existed before but not in the same way. When new models come in old models do not disappear. The fluid technology may be specific and unique but share characteristics with others, a family resemblance, which form continuity. The fluid technology is also a mixture. It is part of other elements which could be fluids themselves. The mixtures however have a need to collaborate with each other if the technology is to work. The collaboration does not have to be rigid and can be flexible and adaptive. Finally the fluid technology has a dissolving ownership. The ownership is fluid in itself allowing the technology the flexibility to have unclear boundaries and multiple identities.

John Urry (2003) has elaborated the concept further by making a distinction between global networks and global fluids. The paradigm example of the first is McDonalds

which is selling its highly standardized products world wide through equally standardized restaurants. Neither are 100% standardized, or 100% immutable mobiles. The products and organizational structures are made immutable mobiles through some local modifications. Networks are change by replacing one component with another while keeping the whole network working. Global fluids, however, are different in the sense that there are more variety across countries (or time and space generally) at the same time as the "objects" are changing like fluids. For Urry, the Internet is the paradigm example of a global fluid. We believe the concept of global fluids captures crucial aspects of an international mobile telecom operator like Telenor.

3. Methodology

The empirical study here was part of research study which took place between Jan 2004 and Mar 2006. In total 78 persons were interviewed (totalling 120 hours) in Norway, Hungary and Ukraine. In addition a total of 155 pages of documents were also studied. Some of the main documents examined were the presentations of the practices that were made to the Telenor companies that were attempting to re-create these practices.
The aim was to examine an event in space and time, a best practice, from the perspective of those that work with the transfer and operation of that practice. The contexts in terms of the market and social factors that influence and are influenced by the practices need to be considered. This led us to using qualitative case study methodology. Firstly, qualitative research seeks to establish meanings of events or phenomenon has seen through the participants (Cresswell 2003). Secondly, in general, case studies are the preferred strategy when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real life context (Yin 2003). Case study methodology is appropriate in our research as we are investigating contemporary phenomenon within its real life context and the boundaries between phenomenon and context are not clearly evident.

Most of the evidence collected was in the form of interviews which from Yin (2003) is the most important source of case study information. Although there were often specific questions or lines of enquiry, the interviews were kept informal and conversational. Documents were used to establish triangulation as being able to use multiple sources of evidence is a major strength of the case study approach and increases its validity (Yin 2003).

In the analysis, to consider a fluid would require considering the multiple identities, changes over time and the changing actors and borders. The practices were examined along with some of the more important components and then back to the whole again. This hermeneutic process (Forster 1994) proved to be useful. In the case of half-rate additional material (books and GSM standards) were reviewed to provide additional context for the full understanding of the practice.

4. Cases

4.1 Case Overview

The two practices come from research made of the Norwegian telecommunications company Telenor. Telenor is a leading provider of communications services and by subscribers the 12th largest mobile operator group in the world. At year-end 2005, Telenor held controlling stakes in mobile operations in Norway, Denmark, Sweden, Ukraine, Hungary, Montenegro, Thailand, Malaysia, Bangladesh and Pakistan. Telenor also held minority interests in Russia and Austria.

In 2002, Telenor made the strategic decision to move from a being a financial owner to an industrial owner. It divested in companies it could not gain majority shares in and increased its share ownership to that of majority in those that it could. Along with this strategy was the setting up of two new units called the Synergy Areas – Products and Markets, and Technology and Operations. The identification and promotion of the two practices, djuice and half-rate is through the involvement of this Synergy Areas group. The Synergy Areas were a means by which Telenor was conducting its industrialization program. Identifying best practices and re-creating them among the companies in the Group was manner of achieving industrialization in the Group. The two practices we shall examine are significant examples of such best practices.

4.2 The djuice youth segmentation model

4.2.1 Background

The origins of djuice go back to the period when most of the major mobile operators were starting mobile internet initiatives. Telenor started an integrated Web and WAP portal called ‘djuice’ in 2000. The name represented digital juice that could be squeezed out of the mobile phone. The djuice portal could be accessed on the mobile phone which in turn could direct users to a variety of services offered by Telenor and third party content providers. The services could be delivered by SMS, WAP and later MMS. The djuice brand (portal, services and concept) was launched by Telenor and its affiliated mobile operators in Norway, Thailand, Malaysia, New Zealand (not by a Telenor affiliate) and Sweden. In Sweden, Telenor launched a MVNO (mobile virtual network operator) operation at the same time and djuice was used as the brand for the whole operation (company name, main brand and mobile services (including the WAP portal)). The mobile internet was expected to grow as fast as the Internet had done in the preceding years and Telenor, along with the affiliated companies invested heavily in promoting the djuice brand and services in all those markets. By 2002 it was clear that the mobile internet was not going to follow the same explosive growth as the Internet had done and Telenor and most of the affiliates, significantly scaled down their activities on djuice.

Towards the end of 2002, Telenor re-evaluated the concept and positioning of djuice. djuice from the beginning had been targeted towards the youth segment which were considered to be the early adopters of new services and technology. This was expanded to

the idea of bundling services along with calling price plans and subscription packages. The djuice (MVNO) operation in Sweden was seen to have been successful at addressing this youth group. The djuice used in Sweden as a mobile price and services plan and the djuice used in Norway as a content service offering was combined with OYO (On Your Own) Telenor's existing youth brand in Norway into a new brand and concept targeted for the youth age group. It was launched in Norway and Hungary in 2003, Ukraine in 2004, Bangladesh in 2005 and Pakistan in 2006. By early 2006, it had reached more than 8 million subscribers in all of these markets combined.

4.2.2 The djuice concept

The new djuice concept catered directly to the needs of the youth with regards to mobile telephony. In order to describe this djuice concept it would be first necessary to understand how that youth segment was profiled. The characteristics the youth are held to have are in relative contrast to other age groups.

The youth have a more technology oriented lifestyle and are more knowledgeable and discerning consumers. They are open to try new things, open to try new technology that is either fun, entertaining, gives them greater availability or has practical use. The youth purchase technology to reaffirm their own perception of their identity. In relation to mobile phone usage, the youth have the mobile phone as a generation icon, it functions as a status symbol and as a tool for fun and maintenance of their social network. The social network is important and being available to friends is crucial (they never turn off their phones). They have a high degree of personalization of phones (a statement of self). They have a high adoption rate and usage of mobile content services, significantly higher SMS (Short Message Service or Text) usage and higher share of mobile-to-mobile calls. The youth are drivers for the most successful premium services (ringtones, logos and sports news). So, djuice is a mobile lifestyle concept with the most relevant and useful voice and value added services for the youth target group. The value proposition and service to customers is presented in an involving way that stresses usability, flexibility and reward (enjoyment/fun). From the djuice Pakistan website:

"*djuice is your mobile brand because we know you are different and like to experience new things. 'djuice' opens doors to a world full of laughter and cheer: its hip, its groovy and its loads of fun. If you like sending more sms and mms and enjoy downloading pictures, ring tones and games to stay entertained on your mobile, djuice is for you*."

djuice consists of several tailor-made elements designed and targeted towards the youth segment. These elements include: configured handsets (own branded menu structure in the handsets, WAP start page and/or menu structure in handset software), an attractive price plan (to cover areas which the youth would find relevant and attractive, such as mobile-to-mobile and SMS), Value Added Service enablers such as Voicemail, SMS, MMS, GPRS and WAP, basic and compelling mobile content. Fig 1 shows some of the services available with djuice in Bangladesh.

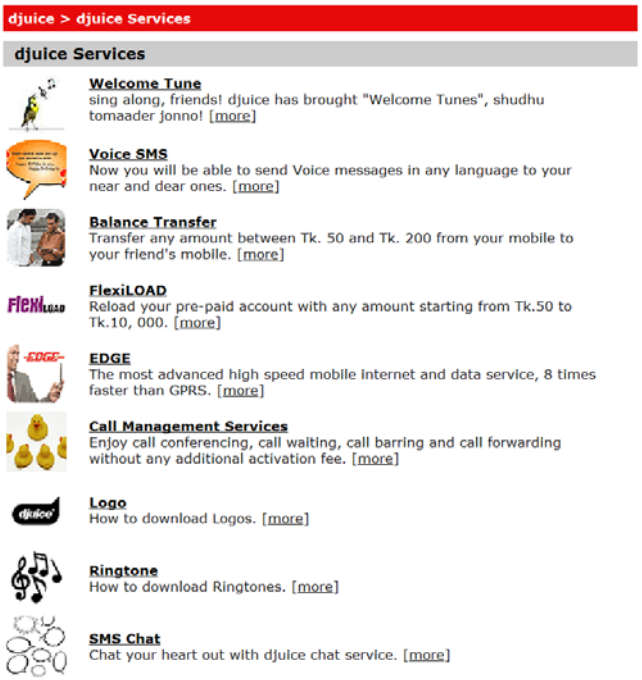


Fig. 1 djuice services (source: djuice Bangladesh http://www.djuice.com.bd/)

Fig. 2 attempts to capture parts of the djuice concept in a diagram. The Djuice concept involves the mobile operator packaging the mobile phone, mobile content, brand and a price plan that matches what the youth segment finds attractive more than the competitor mobile operators would. The Price Plan needs to be balanced in connection with all the other price plans in the mobile operator's product and service portfolio. The djuice price plan should not cannibalize other price plans nor adversely affect the operator's other brands and positioning. It would also need to consider the competitor's price plans and be able to respond to changes that the competition make. Pricing would also have some regulatory issues. The level of pricing also needs to consider the network costs in a balance with regards to making profit and gaining market share. Too low a price could also exceed the network capacity with too many users making too many too calls for too long. If this were to happen, some subscribers would not be able to make calls at all and the quality of the service and perception would be affected. The same would apply for the value added services using voice mail, SMS, MMS and WAP. The Price Plan would also need to be considered in terms of packaging the subscription with a mobile phone. The mobile phone would have to be one that was attractive to the youth group who were 'knowledgeable and discerning' customers. The mobile phone could be configured for easy access to data services and pre-loaded with attractive content. All this would require arrangements with handset manufacturers, content providers and some influence at the distribution and retail channels. The brand communication would need to convey the right image of the technology and its uses in order to match the communication practices, lifestyle and identity of the youth group.

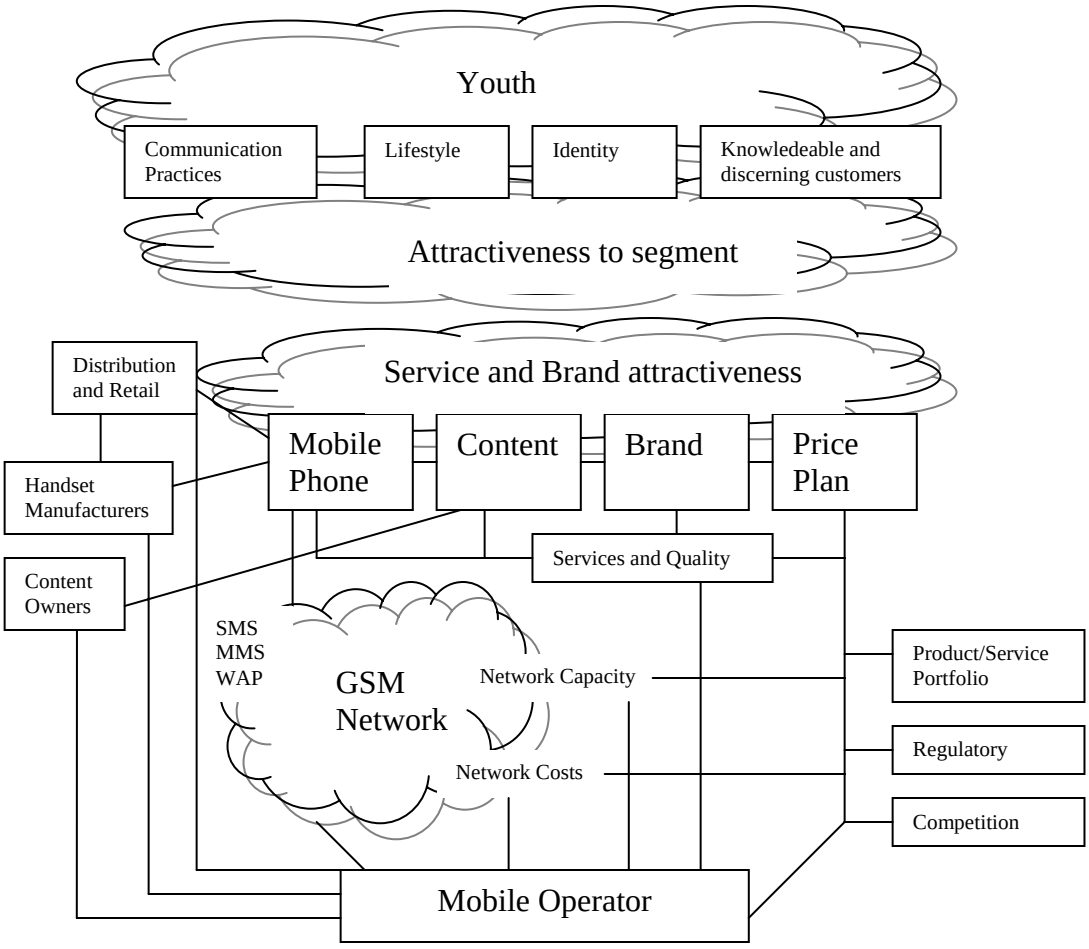


Fig. 2 The djuice concept

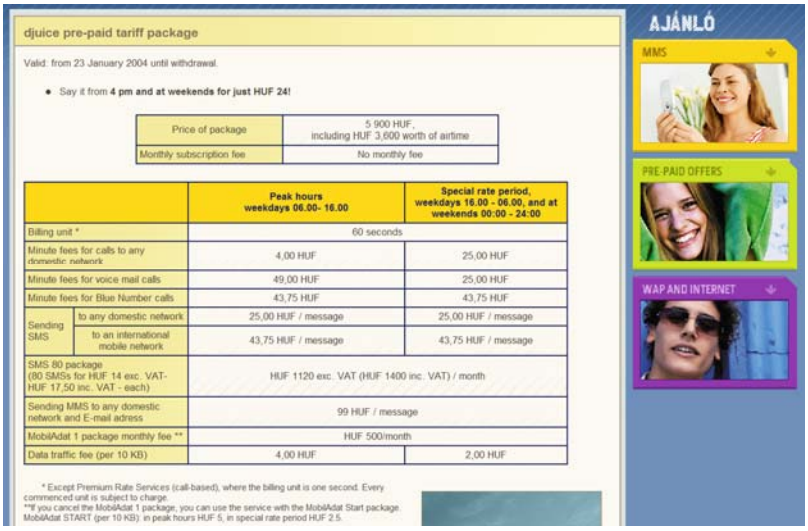
4.2.3 djuice as a fluid

Among other things, for the mobile operator, djuice is an instrument to strengthen its position in the youth market, attract new customers (increase market share), increase adoption of new services (increase ARPU (Average Revenue Per User)), increase customer retention (reduce churn), and strengthen operator brand equity. For the users, djuice is a differentiated mobile and lifestyle offering, a channel to maintain social networks and a mobile community. For content providers and other third party partners, djuice is a revenue generator, a channel to package products and services catered towards the youth, a marketing and co-branding opportunity. For the community djuice is an information network, a way to make modern communication technologies available to they groups that need and use it the most, a social glue that bonds friends and families. With these multiple identities it has multiple borders which change with the identities. Youth trends for example are not constant. As youth trends change new relationships with new entities need to be forged to replace entities which are no longer in fashion in

order for djuice to remain relevant. Market conditions and competitor activities also change over time which would affect revenue generation and increasing the market share. In response to this djuice would need to change its prices and value proposition. The multiple identities also reflect robustness as it is possible to have success based on the different identities. djuice in one market was considered a success in terms of targeting the youth segment and successful in another market in terms of revenue generation with broad mass market appeal. There would be some continuity in terms of previous offerings to the youth segment, e.g. OYO, djuice Sweden and the old djuice. djuice is a mixture of a voice subscription, content, price plan, configured and mobile phone, etc. We will discuss in more detail two central elements of djuice using the fluid concept; the djuice price plan (knowledge) and the mobile phone (technology).

4.2.4 djuice price plan as a fluid

The djuice price plan would have been the outcome of market studies and embody the knowledge and experience of the marketing department and the top management, where pricing matters normally need to be approved. The djuice price plan would have numerous identities. It would a part of the full product and service portfolio of the mobile operator. It would be a tool for gaining market share, gaining revenue, balancing service and quality and supporting brand values. It would be a vehicle to advance mobile telephony services, introduce new services at attractive prices and package services. Fig. 3 shows a section of the price plan of djuice Hungary.


djuice pre-paid tariff package

Valid: from 23 January 2004 until withdrawal.

- Say it from **4 pm and at weekends for just HUF 24!**

Price of package	5 900 HUF, including HUF 3,600 worth of airtime
Monthly subscription fee	No monthly fee

		Peak hours weekdays 06.00- 16.00	Special rate period, weekdays 16.00 - 06.00, and at weekends 00:00 - 24:00
Billing unit *		60 seconds	
Minute fees for calls to any domestic network		4,00 HUF	25,00 HUF
Minute fees for voice mail calls		49,00 HUF	25,00 HUF
Minute fees for Blue Number calls		43,75 HUF	43,75 HUF
Sending SMS	to any domestic network	25,00 HUF / message	25,00 HUF / message
	to an international mobile network	43,75 HUF / message	43,75 HUF / message
SMS 80 package (80 SMSs for HUF 14 exc. VAT- HUF 17,50 inc. VAT - each)		HUF 1120 exc. VAT (HUF 1400 inc. VAT) / month	
Sending MMS to any domestic network and E-mail adress		99 HUF / message	
MobiAdat 1 package monthly fee **		HUF 500/month	
Data traffic fee (per 10 KB)		4,00 HUF	2,00 HUF

* Except Premium Rate Services (call-based), where the billing unit is one second. Every commenced unit is subject to charge.
**If you cancel the MobiAdat 1 package, you can use the service with the MobiAdat Start package. MobiAdat START (per 10 KB): in peak hours HUF 5, in special rate period HUF 2.5.

AJÁNLÓ

MMS

PRE-PAID OFFERS

WAP AND INTERNET

Fig. 3 djuice (Hungary) Price Plan, Source: http://www.djuice.hu/tarifacsomagok/kartyas_en.php

The multiple identities of the djuice price plan have different boundaries which change over time due to changes in the identities. For example, the product and service portfolio changes with new developments within the organization, competition and regulatory bodies. The robustness would be reflected in it being able to successfully be part of the full product and service portfolio without cannibalizing any of the other price plans or be successful at gaining market share. The price plan would share continuity with previous price plans catering for this segment. It is a mixture that includes among others

knowledge of the communication practices and image aspirations of the youth; competitor activities and possible reactions with regards to pricing, i.e. to avoid a price war.

4.2.5 The mobile phone as a fluid

Another element of djuice is the mobile phone. The mobile phone gives security (e.g. knowing a loved one is only a few buttons away and being able to call for help in an emergency); coordination (e.g. who picks up the tickets and getting the right place for the next class); entertainment (with music, jokes, games, etc.); revenue generator (for handset manufacturers, mobile operators, content providers, etc.); a wallet (for m-commerce); interactive television device (voting on reality TV programs, quizzes, etc.); fashion item and status symbol with the top end designer models; a gadget for experimenting with new functionality (including machine-to-machine); a calendar, watch, alarm and scheduler; internet connection; etc. The borders for the mobile phone have become very difficult to keep track of inline with the ever increasing services and functionality that come with it. Given its multitude of devices it is robust with the youth especially taking it wherever they go and always leaving it on. It is continuous with other mobile phones and mobile systems that existed previously. It is a mixture of various technologies (speech coding, radio devices, design, SMS, MMS, WAP, etc.) and knowledge on usage patterns, needs, services, etc. Generally the ownership would start with the handset manufacturer and then to the mobile operator or distributor and finally to the user. Even while it is owned by the user, a large number of its uses depend on access to the network, which is rented out by the mobile operator.

4.2.6 Ownership

On the ownership of the whole djuice, djuice was ‘owned’ initially by its creators in Norway and Sweden. As with any global brand some level of ownership is maintained at a central level but with each operator that has launched djuice in its market also having some ownership. Each person who buys the djuice subscription would be an owner as well. There control as an owner would be in choosing to use or not use the various additional services that djuice offers and whether to continue using or stop the subscription all together. Their response in the market would also have the power to change djuice, as non-performing services would have to be at some point adjusted by the organisation. There would be thus multiple owners with shifting levels of control and influence.

In Mol and Law (1994) ownership of a fluid, in their case anaemia, is not really discussed. In De Laet and Mol (2000) however, dissolving ownership is put forward as a determining characteristic of fluids. In our case of djuice, describing djuice’s ownership in terms of multiple owners with levels of control and influence that shift over time and space would seem more accurate than dissolving ownership. Even in the case of the bush pump in De Laet and Mol (2000), it could be argued to be a case of shifting ownership or even multiple ownerships rather than dissolving ones. The inventor did own in originally, then the manufacturer, then the government, municipality, village or village head. The

design or patent owner could be seen as just one of the many actors that at various times had ownership, control or responsibility over it. It does not really follow that when the other characteristics follow from the multiple identities, that ownership should be construed as a singular unchanging concept. Like in Orlikowski (1992) different owners need not imply discontinuity but continuous shaping and re-shaping based on changing levels of control and influence. This in the case of djuice adds to its robustness. That people want to own it and make it their own contributes significantly to its success and thus robustness.

4.3 Half-rate guidelines

4.3.1 Background

Two major elements of the GSM mobile phone are the transmitter and receiver. In the receiver, voice signals from the user are received by the microphone and sent to the voice encoder. The voice encoder converts the normal voice signals which are analogue into digital signals and encodes the signals using a speech coding algorithm. The encoded digital bit stream then goes through Channel Encoding, Interleaving and Burst Generation where additional bits are added for error correction and re-arranged using error correction algorithms. The bit stream then goes through Ciphering where the bits are encrypted by an algorithm using a unique key in the SIM (Subscriber Identity Module) card. The digital bit stream is then modulated as a pulse so that it can be transmitted through radio frequencies over the air. The pulse is Amplified and sent out through the mobile phone's antenna. Incoming signals to the mobile phone have to go through the reverse process of De-Modulation, De-Ciphering, Re-formatting, De-Interleaving, Channel De-coding and Voice Decoding before being sent to the Speaker as normal speech. Fig 4. below shows the processes involved.

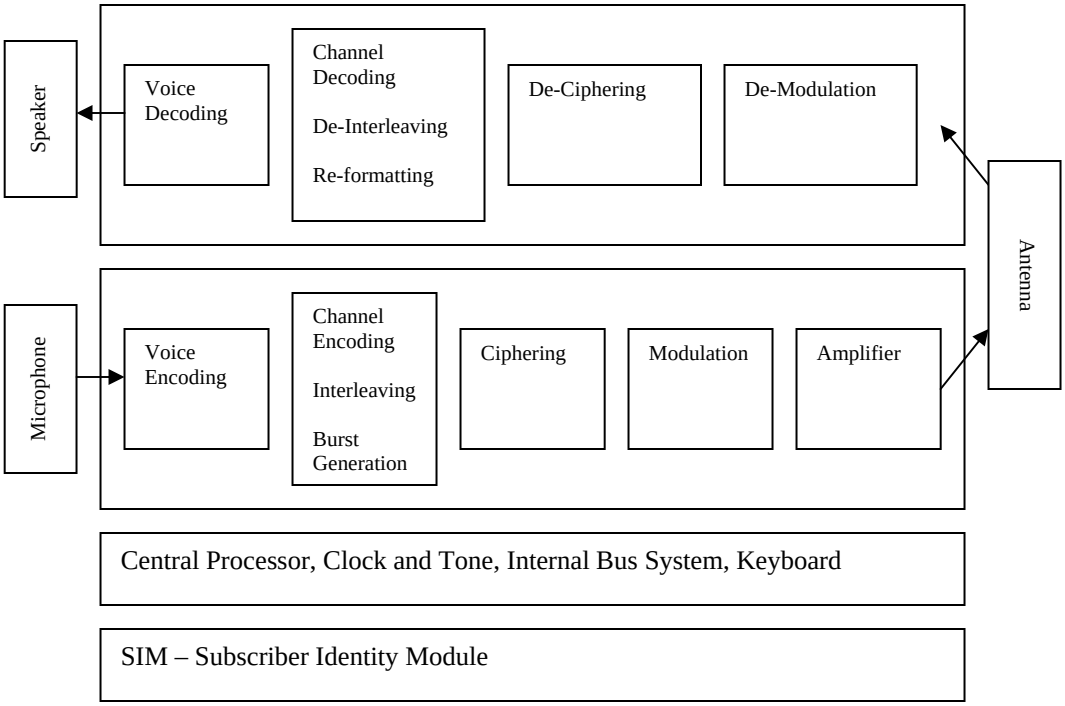


Fig. 4 Elements of a GSM Mobile Phone, Source: Heine (1999)

Our interest is with the Voice Encoding and its consequences. The GSM specifications allow for four different coding based on four different speech coding algorithms. The four are called: full-rate, half-rate, enhanced full-rate (EFR) and adaptive multi-rate (AMR). Full-rate (GSM 06.10 specification) was the first speech coding standard developed by the GSM group (in 1987). Half-rate was developed to cope with the vast growth in subscribers and introduced in the mid 1990's. EFR and AMR were developed later out of greater capabilities in Digital Signal Processing technology allowing for more complex speech coding algorithms. Full-rate uses Regular Pulse Excited – Long Term prediction Linear Predictive Coder (RPE-LPC) speech coding. It provides a transmission speed of 13 Kbps for speech (or 9.6, 4.8 or 2.4 Kbps for data). The RPE-LPC encoder encodes the speech into 260 bit block samples of 20 milliseconds. The full-rate channel supports 22.8 Kbps thus allowing for 9.8Kbps for error protection. Half-rate uses Vector Sum Excited Linear Prediction (VSELP) speech coding. It provides a transmission speed of 5.6 Kbps (or 4.8 or 2.4 Kbps for data). The VSELP encoder encodes the speech into 112 bit block samples of 20 milliseconds. The half-rate channel supports 11.4 Kbps allowing 5.8 Kbps for error protection. (Source: ETSI GSM 06.10, ETSI GSM 06.20)

4.3.2 Half-rate at the mobile phone

Half-rate compresses the speech into bit streams that are about half the size of full-rate (hence the name). Fig. 5 shows the difference between full-rate and half-rate in the traffic

channels (TCH) (which carries the voice and data; the other channel being the control channel (CCH)) through the stages of Voice Encoding, Channel Encoding and Interleaving of the transmission phases in the mobile phone.

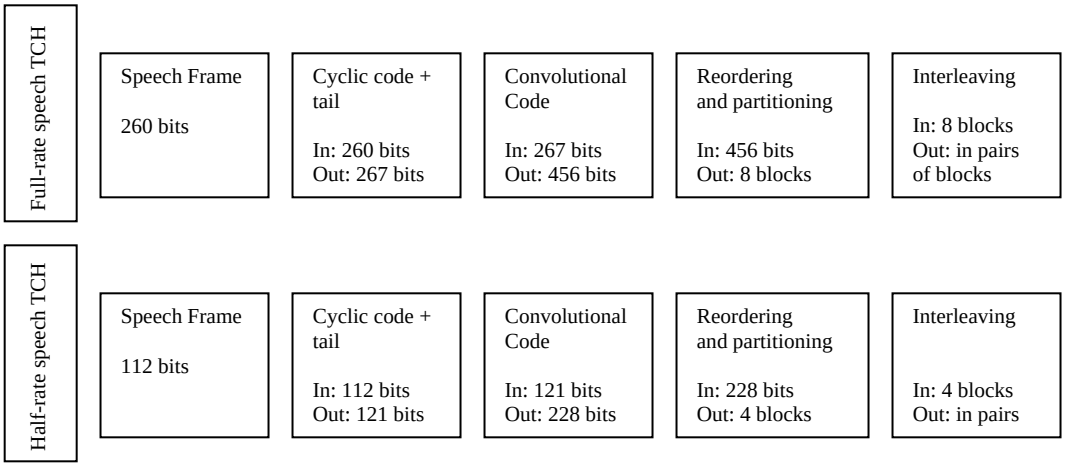


Fig. 5 Channel Coding and Interleaving, Source: GSM 05.03, 1997

The additional compression performed with the half-rate encoding however reduces the quality of the speech compared to full-rate. To offer a comparison, ISDN fixed phone lines can transmit voice streams at 64 Kbps, full-rate at 13 Kbps and half-rate at 5.6 Kbps. The choice between full-rate and half-rate has significant consequences for the mobile operator in network planning and capacity.

4.3.3 Half-rate at the network

From the mobile phone antenna, the bit streams are sent to (and received from) the Base Station System (BSS). The BSS consists of the Base Transciever Station (BTS) and the Base Station Controller (BSC). The BTS contains one or more Transcievers (TRX). The TRX has 8 slots, 1 for control and 7 that are able to handle one call each. Fig. 6 shows these four components of the GSM architecture.

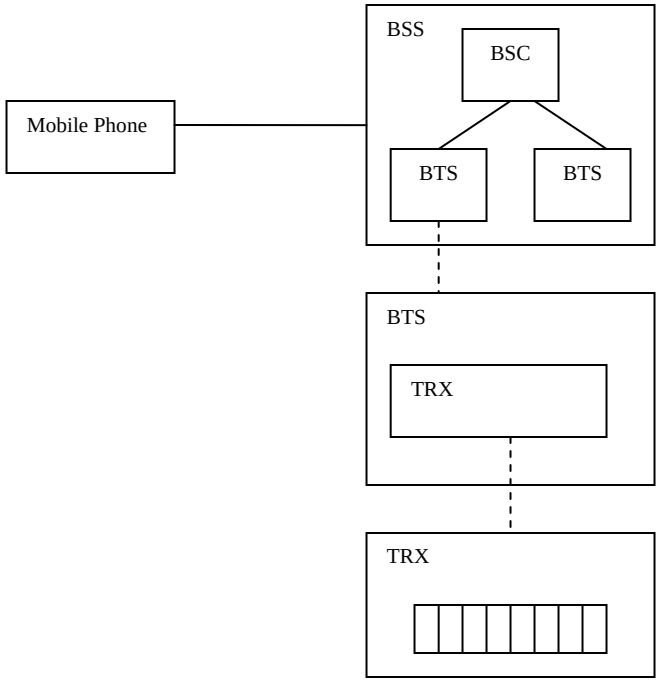


Fig. 6 Components of the GSM Architecture, Source: Lin and Chlamtac (2001)

The TRX is able to handle 7 calls based on full-rate encoding. In half-rate however, each slot is able to handle 2 calls each. The capacity of the TRX would then be doubled and the same equipment would be able to handle twice as many mobile phone subscribers. The price of the half-rate functionality with is software add-on is generally a fraction of the price of a TRX.

4.3.4 The half-rate guidelines

Half-rate was however not generally used among the mobile operators in Norway. The loss of voice quality was one explanation but so was timing. Half-rate was intended to solve the problem of fast expanding subscriber-base but was introduced only in the mid 1990's when mobile penetration in Norway had started to reach saturation. Half-rate functionality also needs to be present on the mobile phone as well as the BSS. For the mobile operator, half-rate could be installed as a software add-on to the BSS, however it was economically and politically impossible to upgrade the millions of mobile phones already out in the market. The cost of doing so could out-weigh the cost savings from half-rate and convincing the users to bring in their phone for an 'upgrade' that could reduce the voice quality of their calls would be very difficult to say the least. Even if the mobile operator had half-rate installed at the BSS, the TRX would be utilised at full-rate if the mobile phone was only capable of full-rate. By early 2000 however, as more phones in the market were enabled with half-rate coding as well, half-rate became a serious option.

Telenor's mobile operator investment in Bangladesh was facing subscriber growth that was outpacing its ability to expand the network. It was also able to get a very attractive deal on the half-rate software functionality from its network equipment vendor. Half-rate was used to the maximum extent possible. The benchmarking results on the utilization of the network attracted the attention of the Telenor head office and together they ran a project to study how best half-rate could be implemented. What resulted was a set of guidelines on using half-rate dynamically in combination with full-rate which at times lowered the voice quality but only when the choice was between lowered voice quality or not being able to make a call at all. The implementation of these half-rate guidelines would enable the operators to be able to utilise the existing network more effectively and was considered a 'best practice' for the organisation. There was however general resistance from a number of companies in the Telenor Group to half-rate. It was associated with poor voice quality and they were afraid of customer dissatisfaction. They would prefer to continue to build the network rather than depend of half-rate. It was however introduced in Ukraine after much deliberation. New versions of the software and improvements in Digital Signal Processing also improved half-rate's speech quality. It was later used in some ski resorts in Norway.

4.3.5 Half-rate as fluid

Half-rate is a software, speech coding algorithm; means of increasing network capacity; revenue generator; creator of low quality calls; and poor man's solution, etc. Its borders change with changes in CODEC (Coder-Decoders) development, DSP (Digital Signal Processing) development, network capacity needs, perception of the degradation of service quality, GSM standards, etc. Its continuity is from the full-rate speech coding algorithm and other speech coding and compression algorithms. It is a mixture of CODEC and DSP integrated circuits, mobile phones, TRX, BTS, GSM standard, network equipment vendors, mobile phone vendors, mobile operators, etc. The ownership from the point of it being chosen and included as a GSM standard took two paths, one at the mobile phone and the other at the network equipment. Mobile phones are mostly owned by users that purchase them but half-rate capability is not mentioned as a phone feature or functionality. The owner has probably no knowledge of its existence. On the network equipment path, half-rate was a software functionality that was purchased by the mobile operator. The mobile operator has control over when to turn it on and for which base stations. But it working depends on the mobile phone having the functionality.

4.3.6 Conflicting Identities

With half-rate the identities do not appear to be pulling in the same direction. The multiple identities do not add up together to increase the robustness. Some of the identities discourage its use and in this case some of the countries Telenor were in were reluctant to use half-rate as it was identified with poor quality calls. Thus unlike the case of the Bush Pump (De Laet and Mol, 2000), here some of the identities are in conflict with each other. It would appear that it is not multiple identities that create robustness but only multiple identities that are aligned together. In the case of half-rate, one identity, that of poor quality calls, discouraged its use. Two other identities, being able to increase

network capacity and increase revenue, encouraged its use. Not all identities have the same objectives or the same criteria for success and failure. In one less use would be the general objective while in the other it would be greater usage. Multiple identities do not always pull in the same direction and would weaken robustness.

5. Conclusion and Implications

Practices which are both knowledge and technology intensive are a reality in the telecom industry. But what does it mean for a company like Telenor to understand their practices as fluids? The answer lies in the fact that to manage a fluid is different from managing a commodity, system or even network. We shall discuss some of the consequences of this in terms of fluid properties.

5.1 Mixtures and Boundaries

A telling quote came from one djuice manager: *"Everything was new. A lot of new people (who just joined the company). No real experience in working in cross-functional projects. For e.g. we would have a meeting on pricing and the technical guy would think this was not for him."* This proved to be especially pertinent as when one of the djuice markets offered 0 rate night calls for a promotion, the network was unable to cope with the subsequent huge surge in traffic. The way they were able to cope was by using half-rate. The mixture of knowledge and technology that is djuice came to include half-rate as well and vice versa. djuice does not have fixed boundaries nor does it have a single static network of relations. Even within djuice, some of its components are also fluid. It is mixture which is dynamic and fluid. The thing to battle against then is too much specialization and SILO thinking. It also contradicts the Lave and Wenger (1991) thinking of communities of practice which tend to favor specialization around narrow frames. What it favors is the 'ensemble' of people (Brown and Duguid 2001) and technology (Orlikowski and Iacono 2001).

5.2 Robustness and Identities

Making a practice robust would be desirable enterprise. It would aid particularly in moving (or transferring) the practice from one context to another. A major part of the rationale for developing best practices would in fact be to re-create them in different organizations. Both djuice and half-rate were in fact involved in such processes. Robustness is a critical property of a fluid for it is what that holds it together. As we have shown in the case of djuice, robustness is aided by aligned identities and in the case of half-rate weakened by conflicting identities. Examining a practice by its identities and the identities of its components is different from examining the entities directly. A study of the mobile phone will be very different from a study of all the identities that the mobile phone has. For Telenor, when it comes to transferring a practice from one company (in one country) to another; a pertinent question to ask is what identities does this practice have in the new context and are any in conflict. A practice may simply have the identity of being seen as something that is forced from the head office which would discourage its use. This identity could have nothing to do directly with the practice or the benefits that

could be derived from it. Thus identities do provide an interesting area to examine difficulties and deal with them with regards to transfer of best practices.

5.3 Ownership

The flow of a fluid is dependent on shifting ownership, control and influence which affects its movement. Once again in the transfer of best practices, attention needs to be paid not just to the transfer of the practice but to the movement of ownership, control and influence.

References

Alavi, M. and Leidner, D. E. "Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues," MIS Quarterly (25:1), March 2001, pp. 107-136

Brown, J.S. and Duguid, P. The Social Life of Information, Harvard Business School Press, 2000

Brown, J.S. and Duguid, P. "Structure and Spontaneity: Knowledge and Organization," in Managing Industrial Knowledge – creation, transfer and utilization, Nonaka, I. and Teece, D (Ed.), Sage Publications, 2001

Brown, R. H. "Social Theory as Metaphor," Theory and Society (3), 1976, pp. 169-197

Cresswell, J. Research Design – Qualitative, Quantitative, and Mixed Methods Approaches, 2nd edition, Sage Publications, 2003

Custer, R.L. "Examining the Dimensions of Technology," International Journal of Technology and Design Education, (5), 1995, pp. 219-244

Davenport, T.H. and Prusack, L. Working Knowledge – How Organizations Manage What They Know, Harvard Business School Press, 1998

De Laet, M. and Mol, A. "The Zimbabwe Bush Pump," Social Studies of Science, (30:2), April 2000, pp. 225-263

Forster, N. "The Analysis of Company Documentation" in Qualitative Methods in Organizational Research – A Practical Guide, Cassel C. and Symon G (Ed.), Sage Publications, 1994

Griffith, T.L., Sawyer, J.E. and Neale, M.A. "Virtualness and Knowledge in Teams: Managing the Love Triangle of Organizations, Individuals, And Information Technology," MIS Quarterly, (27:2), June 2003, pp. 265-287

Heine, G. GSM Networks: Protocols, Terminology and Implementation, Artech House, 1999

ITU Key Global Telecom Indicators for the World Telecommunication Service Sector, 2006, available online: http://www.itu.int/ITU-D/ict/statistics/at_glance/KeyTelecom99.html

ITU, WTI, 2004 available online: http://www.itu.int/ITU-D/ict/statistics/at_glance/cellular04.pdf

Kakihara, M. and Sørensen, C. "Mobility: An Extended Perspective," Proceedings of the 35th Hawaii International Conference on System Sciences, 2002.

Kogut, B. and Zander, U. "Knowledge of the firm and the evolutionary theory of the multinational corporation," Journal of International Business Studies, (34), 2003, pp. 516-529

Lakeoff, G. "The Contemporary Theory of Metaphor" in Metaphor and Thought (2nd edition), Ortony, A. (Eds.), Cambridge University Press, 1992

Latour, B. Science in Action, Harvard, 1986

Lave, J. and Wenger, E. Situated learning – Legitimate peripheral participation, Cambridge University Press, 1991

Law, J. and Law, H. Actor Network Theory and After, Blackwell Publishing Ltd., 1999

Lin, Y-B. and Chlamtac, I. Wireless and Mobile Network Architectures, John Wiley & Sons, Inc, 2001

Lind, M.R. and Zmud, R.W. "The Influence of a Convergence in Understanding between Technology Providers and Users on Information Technology Innovativeness," Organization Science, (2:2), May 1991, pp. 195-217

Mol, A. and Law, J. "Regions, Networks and Fluids: Anaemia and Social Topology," Social Studies of Science, (24), 1994, pp. 641-671

Nonaka, I. "A Dynamic Theory of Organizational Knowledge Creation," Organization Science, (15:1), February 1994, pp. 14-37

Nonaka, I., Toyama, R. and Konno, N., "SECI, Ba and Leadership: a Unified Model of Dynamic Knowledge Creation," in Managing Industrial Knowledge – creation, transfer and utilization, Nonaka, I. and Teece, D. (Eds.), Sage Publications, 2001

Orlikowski, W.J. "The Duality of Technology: Rethinking the Concept of Technology in Organizations," Organization Science, (3:3), August 1992, pp. 398-427

Orlikowski, W.J. and Iacono, S.C. "Research Commentary: Desperately Seeking the "IT" in IT Research – A Call to Theorizing the IT Artefact," Information Systems Research, (12:2), June 2001, pp. 121-13

Schultze, U. & Leidner, D. E. "Studying Knowledge Management is Information Systems Research: Discourses and Theoretical Assumptions," MIS Quarterly (26:3), September 2002, pp. 213-242

Urry, J. Global Complexity, Blackwell Publishing Ltd., 2003

Wise, G. "Science and Technology," Historical Writing on American Science, Osiris, 2nd Series, (1), 1985, pp. 229-246

Yin, R. Case Study Research - Design and Methods, Sage Publications, 2003