A Framework for Tracking Mobile Communication Technology Trends

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Abstract

This contribution presents a qualitative research design approach to track rapidly emerging, converging and diversifying mobile communication technology trends. A conceptual framework is developed as parameter-setting research-design, as a pre-empirical procedure to be used in subsequent full-blown empirical research. Conceptual frameworks are typically used to plan research methodologies with the aim of solving problems around the deployment of new technologies. Such frameworks are useful to begin studying emerging 'interdisciplinary' phenomena for which disciplinary boundaries have not yet been established, or to study rapidly developing phenomena like the development of mobile communication technologies.

Keywords: Apps, conceptual framework, convergence, emergence, emergent properties, Gartner's Hype cycle, mobile communication, problem-solving research, qualitative research, techno-pessimism, techno-realism, techno-utopianism, Venkatesh's Technology Acceptance Model

Introduction

One of the problems with tracking emerging and converging forms of mobile communication technology is the extremely rapid rate with which such technological innovations progress. This no doubt is because mobile communication technology is the most recent of the communication

technologies. It stands to reason that one has to develop a robust and coherent framework for this type of study. This project therefore implements a problem-solving conceptual framework design to account for emerging and converging forms of digital mobile communication technology.

Saunders (2003) defines a conceptual framework as the 'an organization or matrix of concepts that provides a focus for inquiry'. Conceptual framework design is a viable methodology when studying rapid change, and serves as precursor for a subsequent full-blown empirical study of the change process. The function of conceptual frameworks like this one is to lay the groundwork for a subsequent comprehensive empirical study incorporating qualitative or quantitative research methods or the combination of both.

The project takes as point of departure Klopper and Lubbe (2012)'s problem-solving research design, which requires that researchers formulate a problem statement from which key terms are extracted and subsequently used as literature review search terms. According to Klopper and Lubbe (2012), research begins at the stage of total ignorance and further progresses through various stages until one reaches an expert level of knowledge on the topic. These stages are referred to as 'levels of competence when completing a conceptual task'. Emergence is a new area of research where little formal academic research has been done to date. Key terms have been identified from the project's problem statement and extracted from the problem statement to conduct searches for relevant literature about the problem under investigation.

Establishing the Viability of the Research Topic

To determine that the *topic* of emerging and converging mobile communication trends was viable a number of searches were conducted within five academic research databases, namely *Google Scholar*, the University of KwaZulu-Natal's *iLink* library catalogue, the NRF's NEXUS database of on-going and completed research, the *J Stor*, and *Science Direct* scholarly databases, using combinations of search terms like:

- Dissertation + 'emerging and converging forms of mobile communication'

- Thesis + 'emerging and converging forms of mobile communication'
- Paper + 'emerging and converging forms of mobile communication'
- Research + 'emerging and converging forms of mobile communication trends'
- Report + 'emerging and converging forms of mobile communication trends'

The search queries conducted at the above three databases, initially conducted on Wednesday 24 August 2011 and repeated on Friday 1 November 2013, returned zero-references search result like: 'Your search – *dissertation + 'emerging and converging aspects of mobile communication'* - did not match any documents'. Not unexpectedly, a Scholar Google search gave the same result, as did the University of KwaZulu-Natal's *iLink* library catalogue, the *J Stor*, *Science Direct* and similar database searches.

The absence of credible, peer reviewed academic sources on this topic has the following three implications for this study:

1. It is clear that this topic has not yet been researched, either locally or internationally.
2. After the sparse sources that can be identified have been reviewed, non-peer reviewed sources will also be consulted, albeit with care.
3. Because developments around mobile communication technology is a recent phenomenon, not enough may be known about the process by the general public or even students of Informatics to provide information to help solve the problems that have been identified. Therefore, a type of exploratory research known as conceptual framework design would be appropriate.

Problem-solving Research

Problem-solving research requires the formulation of a robust problem statement, and subsequently subjecting it to systematic content analysis in

order to derive key concepts to be used as search terms in order to identify literature that relates to the problems under investigation.

Statement of Problems

Problem statements are best formulated within the framework of some guiding and constraining theory (Gregor 2006). When new information technologies are deployed, an information systems theory, like for isntance Venkatesh's Technology Acceptance Model, ought to be used to guide research on how technology adopters (end-users) will accept and use a new technology (Venkatesh 2003).

Venkatesh's model is a *technology adoption* model and can therefore not be used directly to study *technology emergence and convergence*. It can however, be used to figure out what an empirically testable model of technology emergence and convergence should look like. A theory of emergence and convergence has to accommodate statistics on technology adoption trends. Technology adoption would be one of the factors that influences rates of technology emergence and convergence.

Technology may have both positive and negative influences on society. The United Nations and Vodafone formed a partnership to use innovative technologies to tackle the world's most difficult problems. This partnership is helping the United Nations achieve the Millennium Development Goals and tackle key health, social, environmental, and development challenges. 'Technology especially wireless communication is crucial to finding solutions to these problems. It can connect families separated by disaster, help emergency relief workers respond more quickly, empower farmers to ask for better prices in markets, help track the impacts of climate change, and so much more' (Kinkade *et al.* 2008).

The future impact of technology will play a vital role in how people will live their everyday lives. Currently, one of the main issues is the global focus on climate change and has led to corporates being more aware of their environment and the technologies they use. 'The next quarter century will see the fastest technological change the world has ever known. How will that affect our lives? In general, as Arthur C. Clarke once pointed out, people exaggerate the short-run impacts of technological change and underestimate the long-run impacts' (Cairncross 1997).

One of the more recent trends in the mobile domain is mobile for smartphone applications (apps). Major smartphone manufacturers like Apple, Google, Nokia and Blackberry have shifted their emphasis to mobile applications. Apps allow users to customize their smartphone to suite their everyday and/or business needs. The application business has become the business with the fastest turnaround time, to a global community of enthusiastic downloaders. According to Joshi & Sharma, 2010: 'In January this year, apps were downloaded from the Apple app store 3 billion times, which has more than 100,000 app titles in categories such as games, business, news, sports and health'.

The Epistemological Grounding of the Research Design

The research design framework proposed here is based on the epistemology of emergent properties as part of systems theory, a generic, flexible approach to studying systems. It is applicable to any complex system that has interrelated coherent parts that require synergy to function as a system, which takes materials as input, performs operations on them and produces products as output.

The crucial idea of the emergent properties of systems is that productive systems are not static entities, but they themselves change (evolve) over time in order to remain fit for purpose to produce new outputs according to predesigned, updated plans in response to ever changing environments.

Examples of such systems are factory assembly lines that systematically assemble component parts based on plans to produce products, alimentary canals that take food as input, converts some of it into energy as end-product, while excreting excess by-products in a variety of ways (defecation, urination and sweat), the design and manufacture of mobile communication devices that have comparable inputs, by-products and end-products, and finally using the principles of research design to plan a research project for generating new insights about problems under investigation. One of the originators of the philosophy of emergence, Mill (1843) describes the philosophy of emergent principles as follows:

All organised bodies are composed of parts, similar to those composing

> inorganic nature, and which have even themselves existed in an inorganic state; but the phenomena of life, which result from the juxtaposition of those parts in a certain manner, bear no analogy to any of the effects which would be produced by the action of the component substances considered as mere physical agents. To whatever degree we might imagine our knowledge of the properties of the several ingredients of a living body to be extended and perfected, it is certain that no mere summing up of the separate actions of those elements will ever amount to the action of the living body itself. (A System of Logic, Bk.III, Ch.6, §1)

Theories Compatible with the Philosophy of Emergent Properties

The following theoretical frameworks seem to be compatible with the philosophy of emergent properties, and therefore have the potential of serving as guiding and constraining frameworks for the study of the emergence and convergence of mobile communication:

- Agency Theory (Alchian & Demsetz 1972; Eisenhardt 1985, 1989; Shankman, 1990; IEA 2007, Murtishaw & Sathaye 2006);
- Change Theory (Shackman *et al.* 2002, 2012; Ruiz 2013);
- Diffusion of Innovation Theory (Pemberton 1936; Rogers 2003; Greenhalgh *et al.* 2004);
- Lewin's Three-step Change Theory (Lewin 2011; Kaminski 2011); and
- Prochaska and DiClemente's Stages of Change Model (Singer 2009).

The Overall Problem Statement

Only limited research has been done to date regarding the general problem under investigation about the emergence and convergence of mobile forms of communication. There had been little success in finding a conceptual

framework for the forms of mobile communication through a process of elimination in the literature survey.

Subproblems

Subproblem 1

- There is no systematized information available at present about a conceptual framework to track emerging and converging of digital mobile technologies.

The topic being researched is a new one and as a result there is no information available on the university's electronic journal database about conceptual frameworks for tracking the emergence and convergence of mobile technology. To substantiate the above, as mentioned earlier, an advanced search on Google Scholar, iLink, J Stor, Science Direct and similar database searches were performed for the search term 'conceptual frameworks for tracking the emergence and convergence of mobile technology', with no exact matches.

Subproblem 2

- Neither the positive nor the negative impacts of emerging and converging digital mobile technologies on society have been studied yet.

With the rise of emerging and converging technologies, there have been many uses and applications for these devices. This research project will also identify how new mobile technologies will influence society. In contrast, there have been some negative aspects for adopting new mobile technology services.

Subproblem 3

- It has not yet been established what the best framework would be to track the impact of future technologies on society.

The current pace of technology deployment is fast changing the way in which society live. Technology plays a key role in both emerging and mature markets. For example, the mobile phone has made it possible to communicate and provide transaction services in some rural areas of Africa. In mature markets, technology is embedded in the city's infrastructure, for example, the availability of broadband at high speeds.

With technology playing such a vital role in everyday life, computers are used for business, leisure, socializing and many more. Computer devices have many functions in a society of ubiquitous computing. Technologies are being rapidly deployed with faster processing times and smaller in sizes. It is no surprise that the mobile phone encompasses many converged technologies in a single device. As stated at the beginning, there are no exact matches for the term 'conceptual framework for tracking the emergence and convergence of digital mobile technologies', both on the web and Google Scholar.

Problem-Research Question Alignment Matrix

Unless research questions are derive from and properly aligned with one's subproblems, the empirical phase of research will be incompatible with the design phase and the results will not help solve the problems that prompted the research.

Gen. Problem	Subproblems	Research Questions
The *general problem* under investigation is that as yet there does not exist a coherent framework to track the emergence and convergence of digital mobile technologies.	1. There is no systematized information available at present about a conceptual framework to track emerging and converging digital mobile technologies	1. What is the nature of a conceptual framework that would accommodate the study of tracking emerging and converging digital mobile technologies?
	2. Neither positive nor negative impacts of emerging and converging digital mobile technologies on society have been studied yet	2. What are the positive and negative impacts of emerging and converging technologies?

	3. It has not yet been established what the best framework would be to track the impact of future digital mobile technologies on society	3. What framework could be used to track future digital mobile technologies impact on society?

Table 1: Problem-research question alignment matrix based on (Klopper & Lubbe 2012)

Research Design

Research design forms part of the planning phase of research. It provides the overall structure for the procedures the researcher intends to follow, the data the researcher intends to collect, and the data analysis the researcher intends to conduct (Leedy & Ormrod 2010). This section therefore describes the *planning* of the research process. By contrast with 'research design' the term 'research methodology' refers to the *execution* of the envisaged research process. The term 'methodology' therefore covers the actual empirical procedures for gathering, analysing and interpreting data – choosing a sampling frame, gathering a representative sample of data with an appropriately designed research instrument, systematically analysing the data and applying the appropriate statistical tests to establish valid interpretations for one's data.

Whereas 'research design' precedes one's literature review, one's actual research methodology is best implemented *after* one's literature review, so that one can determine whether any problems that one has identified have not yet been solved by other researchers. This sequence is illustrated in Klopper (2012). It is important to note that the research design may have to be adjusted due to findings in the literature review.

Envisaging a Coherent Research Design Process

Problem-solving research proceeds along five stages.

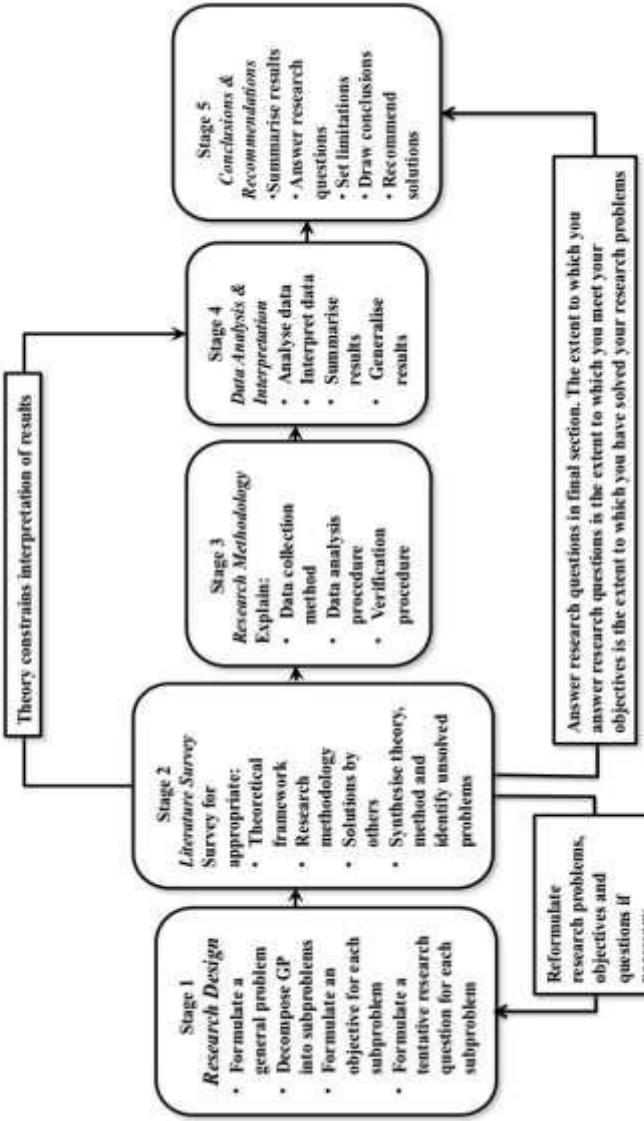

Figure 1: The research process step-by-step adopted from Klopper (2012)

- **Stage 1:** Formulate the problem, decompose it into interrelated sub-problems, derive research objectives and research questions from it.

- **Stage 2:** Do a full literature review.

- **Stage 3:** Design research survey instruments and submit them to organisation for ethical clearance. Conduct fieldwork, and document research methodology.

- **Stage 4:** Analyse, interpret data and assess results.

- **Stage 5:** Collect data, analyse data, determine significance of inferential relationships, assess results and write up research report.

The process of envisaging the five stages of problem-solving research is visually represented in Figure 1 above.

In the course of having served as postgraduate external examiner for several South African universities, I have concluded that many students (and their supervisors) are not quite clear about the nature of problem statements and that they are routinely confused with research questions. Logically problem statements are propositions, while linguistically they are assertions. According to the semanticist John Lyons (1978:142):

- 'A proposition is what is expressed by a declarative sentence when the sentence is uttered to make a statement'.

- 'Propositions may be true or false'.

The Propositional Structure of Statements

What problem statements are not:

- × A problem statement is not a question, e.g., 'Where did the chicken disappear to just before supper?' or 'Why did the chicken disappear just before supper?'

- × A problem statement is not an objective, e.g., 'To determine how the chicken disappeared just before supper'.

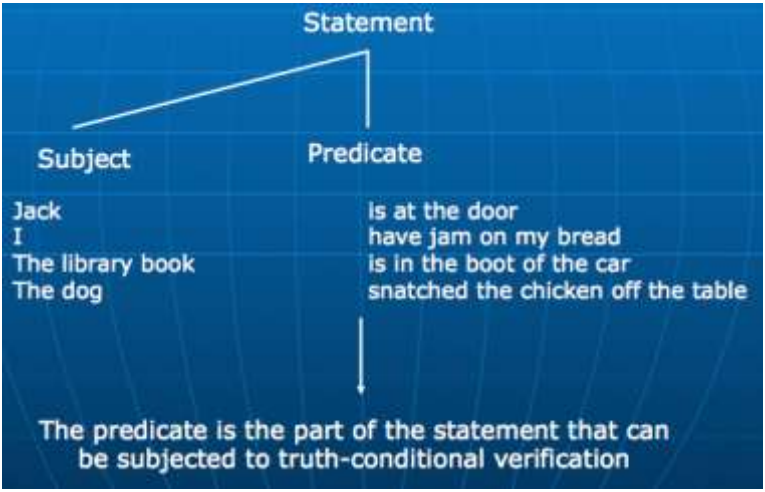

Figure 2: The propositional structure of statements (own formulation)

Identifying Literature Sources by means of Key Concepts

Literature should be identified through key concepts extracted in one's problem statement. Due to the nature of the study, there are many fields of study that impact the emergence and convergence of technology. However, the majority of the literature falls under the fields of social media, mobile computing and information systems. Since this is a pre-empirical study with the intention to set up a subsequent full-blown empirical study.

Identifying Mobile Devices and Mobile Software (Apps)

Fenn and LeHong (2011) note that various new technologies have gained significant momentum since 2010, including augmented reality, cloud computing, social analytics, Internet TV, location based services and E-Book readers. The top 10 largest mobile manufacturers in 2011 were Samsung, Apple, Nokia, LG, Sony Ericsson, HTC/Google and BlackBerry. In the

current mobile market, all smartphones use mobile applications. Most developments happen on various platforms:

- Symbian
- Android
- Windows Mobile
- iOS
- Java ME

Identifying Visual Sources for Content Analysis

From hermeneutic point of view visual representations – sketches, photographs or video material – are texts that contain information just like written texts, although the mode of information representation differs from text type tot text type. Visual texts in the form of videos were identified to form part of literature survey by means of three related key terms derived from the problem statement, namely: *techno-utopianism*, *techno-realism* and *techno-pessimism*. The visual texts identified below are *examples* of the videos that can either be subjectively interpreted as literature review sources, or that can be systematically analysed as primary information sources by means of content analysis.

The content of first video is summarised in enough detail to enable the identification of content categories for subsequent systematic content analysis. For the rest of the videos, only concise notes are provided to serve is mnemonics for subsequent systematic content analysis. The length of a particular summary will depend on the nature and length of the particular video. The primary source of videos about mobile communication devices would be www.youtube.com and www.ted.com.

Video Title	Source	Category
Productivity Future Vision (2011)	http://www.youtube.com/watch?v=a6cNdhOKwi0	Techno-utopianism

A woman walks towards a taxi rank while a voice is welcoming her to Johannesburg International Airport in Afrikaans. She then reaches for a button on her glasses that indicate that it is translating and the voice switches

from Afrikaans to English. She steps into a vehicle where the time is displayed in the bottom corner of the window and takes out her mobile device. With the movement of her hand and finger she draws a heart above the mobile device that then interprets the image as a heart on the screen and places it onto the 'Kitchen Wall'. Her finger slides across the screen that switches to the hotel check-in, she checks in and is notified of her digital room key, as well as her room being ready. The scene then switches to a gentleman who takes out his mobile device that tells him information about the guests who are arriving such as minutes to arrival, number of guests, number of bags and weight of the luggage. Another swipe shows the image of the woman and her name 'Ayla Kol' with time of arrival information in minutes. The gentleman then turns his card around for additional information on the woman's stay and displays information such as guest details, service level, travelling from, favourite amenities and flight time. The screen switches back to the woman and she has received a message from a work colleague, Qin who needs an urgent response for his message. She then replies voice to text and this is identifiable through the instructions displayed on the screen, showing 'Transcribing'. The woman then arrives at the hotel.

The next scene switches to a gentleman at a train terminal and he is looking at his re. He clicks on a button, 'Get Coffee' and the mobile device then provides him with a map and directions. He then slides his finger to display a voicemail message that has been transcribed. The message displays, 'Can you approve the order today?' and the gentlemen then is presented with a dial that he scrolls to '40 Litres' and place the order with a click of a button. He then turns to an interactive advertisement, he places the mobile device... and is then prompted to donate '20 HK$'.

On the next scene it switches back to the woman in her hotel room where she walks towards a 'smart-desk' (similar to Microsoft Surface) and reaches for her mobile device which has a reminder activated. She then picks up a larger mobile device about the size of an open A4 magazine. The woman is working on a presentation where she is copying and pasting items with a touch of a finger as well as switching between pages with a slide of a finger. The woman then sends a message to a gentleman who seems to be working in a research type environment and he then calls her into a conference call where the gentleman can see two women also on the call. The gentleman then works with the information in a 3D like environment and

controls the information with hand gestures. Another gentleman approaches the researcher and they are able to transfer information between the two separate screens via finger slides. After they have collated the information the system makes a decision based on the information provided.

The next scene shows a child solving mathematical problems on a mobile device in an interactive fashion where the correct result resulted in a form of animation on the screen. A gentleman walks into the room and interacts with the fridge door. The child then does a search for recipes on her mobile device by typing, 'Help me find a Recipe' and shortly another application starts populating with recipes. The child then sends a message to her mother, who is the woman in the hotel room, to find a special recipe; the woman is the child's mother. The mother then picks up her mobile device and has a video conversation with her child. The scene then changes to the gentleman who touches the fridge door which becomes transparent and displays what's inside as well as what groceries have been ordered. The daughter then selects the option to find more recipes that are similar to apple pies, and the same information is displayed to the mother, which helps her decide on a recipe.

Video Title	Source	Category
Fabian Hemmert: The shape-shifting future of the mobile phone.	http://www.ted.com/talks/fabian_hemmert_the_shape_shifting_future_of_the_mobile_phone.html	Techno-utopianism

Hemmert demonstrates one future of the mobile phone - a shape-shifting and weight-shifting handset that 'displays' information nonvisually, offering a delightfully intuitive way to communicate. Fabian Hemmert studies the theory and philosophy of embodiment, resistance and thinghood.

Video Title	Source	Category
Jan Chipchase: The anthropology of mobile phones.	http://www.ted.com/talks/jan_chipchase_on_our_mobile_phones.html	Techno-utopianism

Nokia researcher Jan Chipchase's investigation into the ways we

interact with technology has led him from the villages of Uganda to the insides of our pockets. He's made some unexpected discoveries along the way. As principal researcher for Nokia, Jan Chipchase travels around the world and inside our pockets in search of behavioural patterns that will inform the design of products we don't even know we want.

Video Title	Source	Category
Arthur C. Clarke Predicting The Future in 1964.	http://www.youtube.com/watch?v=AOaZspeSBZU	Techno-utopianism

The above video is taken from a BBC Horizon programme in 1964, where Arthur C. Clarke predicts the future. This black and white video see's Clarke in front of the camera describing how the future will be in 1964. The video looks at various aspects of the future such as cities of the future.

Video Title	Source	Category
Mobile Technology.	http://www.youtube.com/watch?v=orPYB741sqY	Techno-Realism

The Mobile Technology video is a short animation video presenting statics and future predictions about mobile technology.

Video Title	Source	Category
Did you Know? – Mobile Stats. For Africa.	http://www.youtube.com/watch?v=5kamlf-uAHU	Techno-Realism

The 'Did You Know?' is a presentation on statistics with regard to increased use of mobile phones in Africa over the past five years.

Video Title	Source	Category
The Growth of Mobile: The Stats and figures will shock you!	http://www.youtube.com/watch?v=0aUQLIPdtg8	Techno-Realism

Sybase Inc. created the video and like the previous video presentations it also discusses statistics and makes predictions about the future based on various mobile statistics.

Top Selling Mobile Handsets in 2013

Part of the preparation for empirical analysis is tracking the top selling mobile phone handsets since 1992 when the first mobile phones came on to the market. By way of example the statistics for 2013 are given:

1. Samsung Galaxy S4, over 39 million sold
2. Apple iPhone 5, over 20 million sold
3. HTC One, 5 million sold
4. Nokia Lumia 520, over 4 million sold
5. BlackBerry Q10, 3 million sold
6. Sony Xperia M, 2.1 million sold

Mobile Phone Manufacturers

Only four mobile phone manufacturers, shown on table 2 below, account for millions of mobile applications (Ruiz 2013), directly available for download on the major platforms. Some appsare available for download for free whereas other apps require users to pay for them. Applications are available through their various branded stores is given on Table 2 below:

#	Mobile Application Manufacturer	"Store" Name	Logo	URL	Programming Language built on:
1	Apple	App Store (via iTunes)		Available in iTunes: http://www.apple.com/itunes/	Xcode Suite (supports C, C++, Fortran, Objective-C, Objective-C++, Java, AppleScript, Python and Ruby)
2	BlackBerry	App World		http://appworld.blackberry.com/webstore/	Java
3	Google	Android Market		http://www.android.com/market/#app=com.wsl.CardioTrainer	Java
4	Nokia	Ovi Store		https://store.ovi.com/	Symbian C++ & Windows Mobile[1]

Table 2: Mobile phone manufacturers in 2013 in alphabetical order

Mobile Technology Companies

Table 3 below shows 94 companies that in 2013 are active in the mobile communication technology (MCT) market, as hardware technology designers, producers, manufacturers or distributers. The information on the table was documented from a variety of sources – Internet web sites, electronic journal articles, printed journal articles and promotional brochures, to name a few. Because the MCT landscape is constantly changing due to forces of emergence, convergence and diversification, it is not possible to provide a definitive list at any particular time.

A	E	J	Neonode	Sonim Technologies
Acer Inc.	Ericsson	Jablotron	Nexian	Sony Mobile
AEG	Ericsson Mobile	John's Phone	Ningbo Bird	Spectronic
Alcatel Mobile	Ericsson Radio	Jolla	O	T
Apple Inc.	Evertek	Just5	Olivetti	Technicolor SA
Archos	F	K	Onda Mobile	Technophone
B	Fairphone	Karbonn Mobiles	Onida Telit	Telefunken
BenQ	Firefly	Kejian	P	V
BenQ-Siemens	Foxconn	L	Palm, Inc.	Vertu
BlackBerry	G	Lanix	Panasonic	Verzo
Brondi	G'Five	LG Cyon	Pantech	Videocon
Groupe	GeeksPhone	Lumigon	Pantech Wireless	VK Mobile
BYD Electronic	Twig Com	M	Peiker Acustic	Voxx International
C	Gigabyte	M.Mobile	S	W
CECT	Goldvish	MagCom	Sanyo	Walton
Celkon Mobiles	H	Meizu	Sendo	X
Cherry Mobile	HTC	Micromax Mobile	Sharp Corp	Xiaomi
D	Huawei	Mitsubishi Electric	Samsung	Y
Danger	I	MobiWire	Sanyo	Yota
DBTel	IGB Eletrônica	Modu	Sendo	Z
Digital Ocean	Inq Mobile	Motorola	Sharp	Zonda Telecom
Doro Telecoms	Inventec	N	Siemens	Zopo Mobile
	Iriver	NEC	Sitronics	ZTE
		NEC Casio Mobile	Sky Electronics	Zync Global

Table 3: Mobile technology companies in 2013 in alphabetical order

Besides the MCT providers listed in table 3, there are an unknown

(and perhaps unquantifiable) number of apps software programmers, using a variety of distribution channels to sell or give away apps.

Mobile Communication Technology Applications Being Tracked

Time span for mobile phone availability: 1992 – 2013.
Aspects of mobile phones being tracked:

- Mobile Advertising Applications
- Mobile Browsing Applications
- Mobile camera and video Applications
- Mobile Health Monitoring Applications
- Mobile Instant Messaging Applications
- Mobile Music Applications
- Mobile Payments Applications
- Mobile Search Applications
- Mobile TV and Smart TV
- Money Transfer Applications
- Multimedia Applications
- Near Field Communication Applications

Factors that Could Affect Mobile Communication Trends

Gartner (2013) identifies five factors that affect successful mobile instrument deployment:

1. Mobility
2. Interoperability
3. Cloud and Hybrid
4. Broad solution appeal

Prospective Model of Emergence to Account for the Evolution of Mobile Communication

Two prominent models used to study technological change are Venkatesh *et al.* (2003)'s Model of User Acceptance of Change shown in Figure 3 below, and Gartner (2013)'s Hype Cycle for Emerging Technologies shown in Figure 4 below:

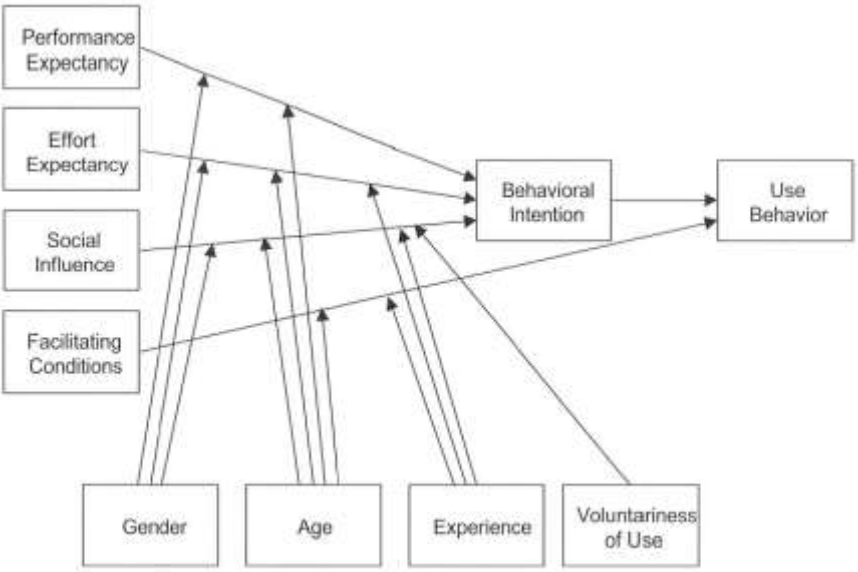

Figure 3: Venkatesh *et al.* (2003)'s Model of User Acceptance of Change

The Venkatesh technology adoption model allows the researchers to formulate questions in their research instruments that allow them to calculate the likelihood of adoption of the technology, relating to *technology-adopter variables* like the gender, age, level of experience of the adopter, the voluntariness of use and variables that relate to *personal expectations* (the adopter's expectations about the usefulness of the technology under consideration) and the *social influence* leverage that the technology provides, plus additional facilitating conditions. Arrows indicate which social factors ought to be correlated with which perceptual factors. Wamuyu (2010) and

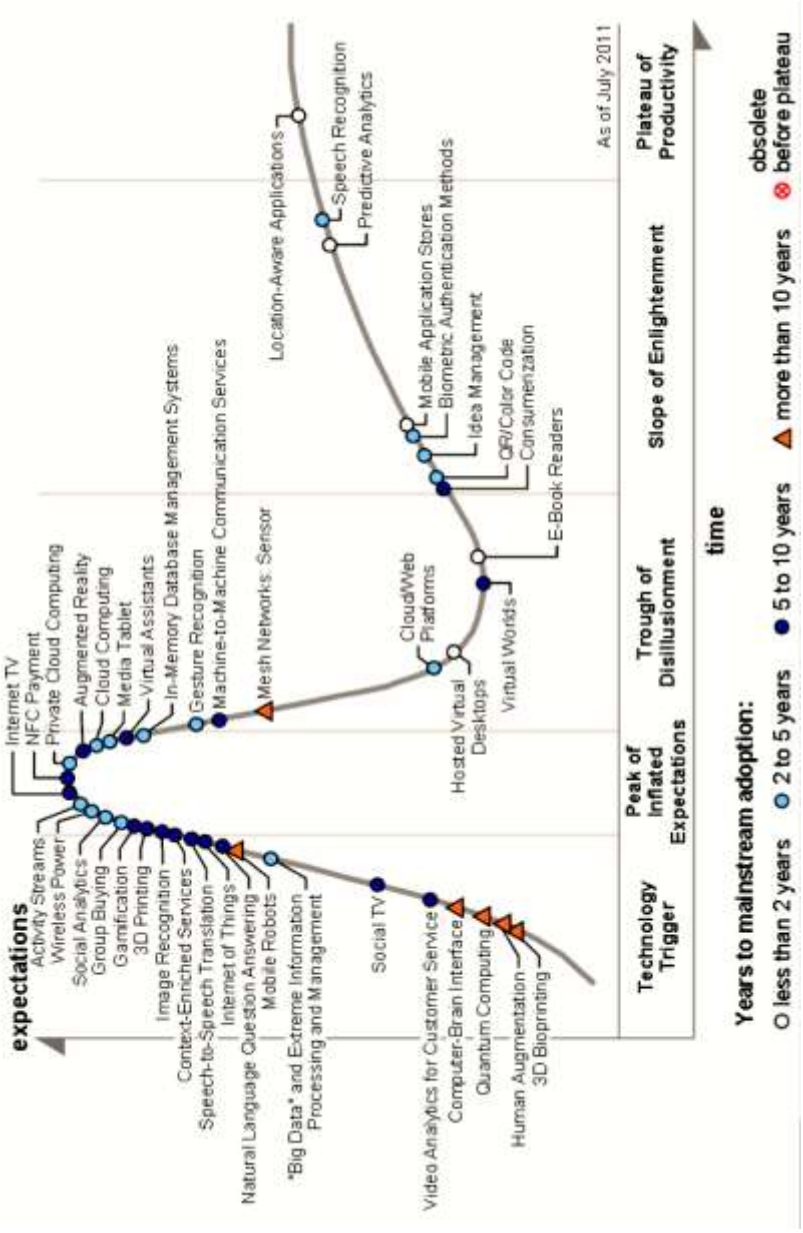

Figure 4: Gartner (2013)'s Hype Cycle for emerging technologies

Wamuyu and Maharaj (2011) show how the Venkatesh model can be applied to study technology adoption. The Venkatesh model however, focuses on end-user perspectives about technology adoption, not on technology *per se*.

The Gartner Hype Cycle for adopting emerging technologies, shown in Figure 4 above, plots in considerable detail, the adoption of a wide variety of emerging technologies against a dynamically adjusted sine curve, based on empirical data (Gartner Inc. 2013).

It is perhaps appropriate that I provide brief explanatory comments about sine wave graphs. Plotted along the vertical X-axis and the horizontal Y-axis, generic sine wave graphs are used to show changes over the longitudinal time-lapse t-axis, shown in Figure 5 below. Sine waves are typically used to represent the propagation of light waves, changes in air pressure as sound travels through the air, or fluctuations in the price of a particular share over time:

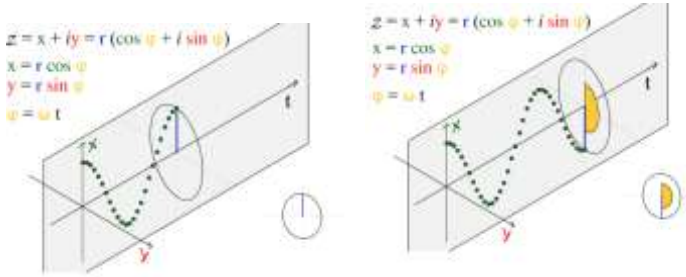

Figure 5: Sine wave propagation of changes over time adopted from Wikipedia 2013 entry, Sine Wave

For natural phenomena like light waves the repetitive cycles remain concentric as long as there is a constant light source. In the case of share price trends, or people's expectations of different technologies, the sine curves are dynamically adjusted to reflect changing expectations.

On the vertical X-axis of the technology emergence hype cycle graph in Figure 4 above the measured degree of expectations expressed by respondents regarding a technological innovation is plotted. On the horizontal Y-axis the upward and downward trajectories of the sine wave are determined for each of the factors as respondent perceptions about it change. time that lapsed since the introduction of the innovation. Each plot point on

the curve represents aggregated group-data regarding the expectations that respondents reported about a specific technology.

Over time the plot-points for specific technologies vary according respondents' changed expectations regarding them as they and their performance become better known. For instance, based on survey calculations, at the onset point of the Gartner sine curve there are low expectations for four new technologies: *3D Bioprinting* (using three-dimensional body tissue printing techniques to generate DNA encoded body parts (Singleton 2013; Miller 2013); *Human Augmentation* (using technology to enhance human abilities in order to temporarily or permanently overcome physical limitations through cybernetics and nanotechnology, as is the case with powered exoskeletons – mobility enhancing machines that serve as external frameworks (comparable to the exoskeletons of insects) for enhanced limb movement to deliver energy and extra strength to lift heavy objects); *Quantum Computing* (using quantum-mechanical phenomena like superposition and entanglement to perform operations on data (Ceder & Persson 2013), and *Brain-Computer Interface* through a neural implant, to serve as a direct communication pathway established between the subject's brain and an external device to assist, augment, or repair disrupted human cognitive or sensory-motor functions (Budinger & Budinger 2006)).

Referring back to Figure 4, *Virtual Worlds* and *E-Book Readers* are positioned on the other side of the sine curve in the Trough of Disillusionment, with equally low low expectations as the yet unknown biotechnology devices taht have not lived up to the initial hype (high expectations) shortly after they were introduced. In similar vein, at the top of the sine curve peak are *Internet TV* and *Near Field Communication* (NFC), *Payment* for goods and services by entering the amount owed on the appropriate App installed on a smart phone and touching it against the receiving device of the vendor to conclude the transaction).

Accordding to Fenn & Huang (2011), Gartner Hype Cycle analysis has been used to survey respondents' expectations about a wide variety of technological, social and business innovations: communication service provider infrastructure, consumer devices, mobile devices, mobile applications, application security, consumer technologies, smart city technologies, emerging technologies, e-commerce, human-computer interaction, and solar energy, to name but a few.

Conclusion

1. While the Gartner Hype Cycle model seems to be more flexible than the Venkatesh model to study expectations about innovations, like the Venkatesh model it has the problem of focussing on end-user expectations rather than on the actual attributes of mobile communication technologies.
2. The study of technology emergence ought, at the outset, be grounded on the hard facts of how and when mobile communication technologies emerge, converge and are diversified into next-generation, feature-rich technologies. Only thereafter can sense be made of the soft human dimension of change - inferences about how technological innovations trigger changes in the perceptions, opinions and preferences of end-users that lead to changes in their purchase and usage behaviours.
3. It may therefore be more appropriate to use qualitative content analysis of documents to gain a proper understanding of mobile technology change before technology adoption dynamics can be studied.
4. It stands to be seen if the Gartner Hype Cycle is flexible enough be adapted to study technology change itself rather than perceptions about the consumer behaviours that drive technology change.

In summary, the exploratory review presented in this article of the elements that constitute the emergence, convergence and diversification of mobile communication technology hardware as well as software applications (apps), provides the basis for an empirical study about the stages of technology innovation shown in Figure 6 below. Whatever model is adopted, adapted or devised to guide and constrain empirical research on mobile communication trends, it should be based on general philosophical principles regarding emergent properties, that were already formulated by Mill in1843 and ought to be taken account of.

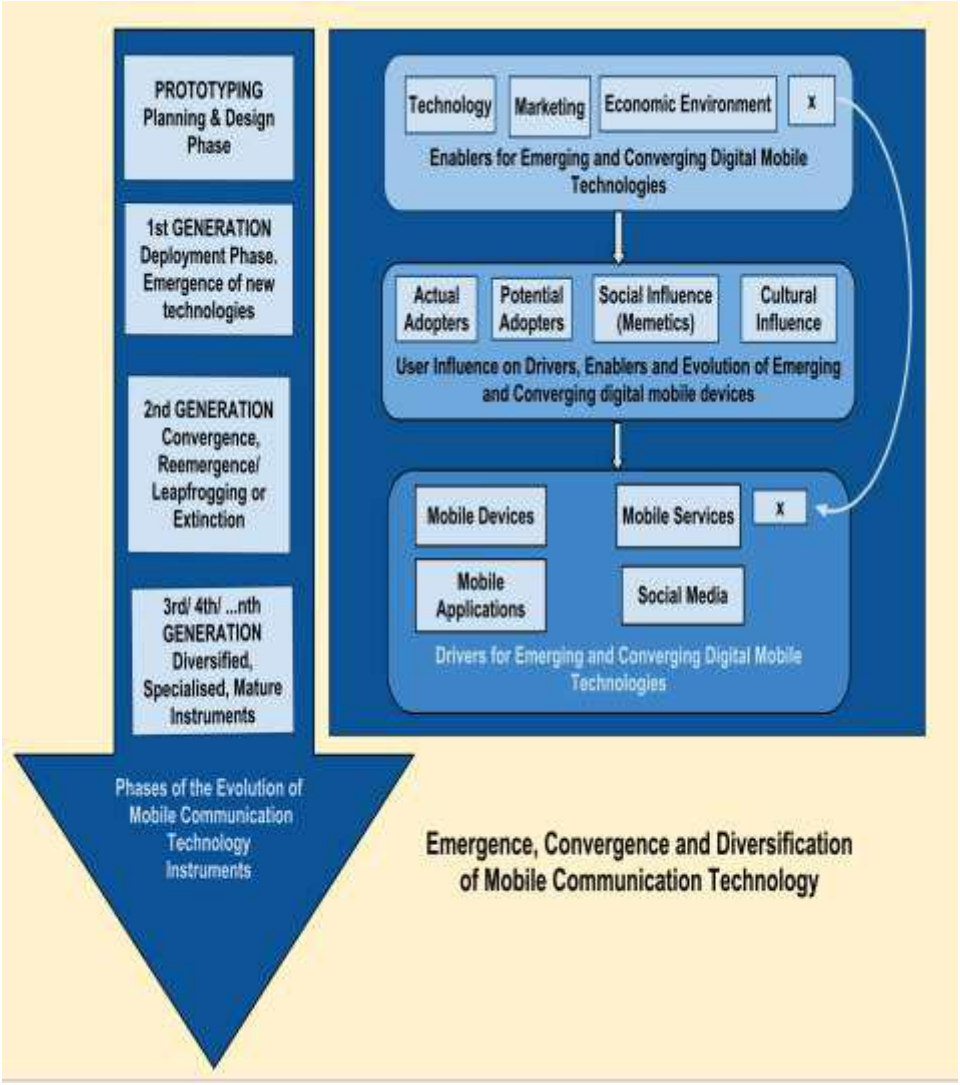

Figure 6: Phases of emerging and converging mobile communication change for which a theory of change should account (author's own formulation)

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