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TO WHOM IT MAY CONCERN

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Measuring the ubiquity characteristics of mobile access channels – Africa and the United Kingdom

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Abstract

A question that is often asked among different role players in the mobile applications industry is: "which access channels should be supported by a mobile application?" A literature survey was conducted to identify available access channels and a number of channels were found. Furthermore it revealed a number of measurable characteristics which could determine the applicability of a specific channel for a specific mobile application. This paper focuses on one of the characteristics: *ubiquity*. A number of access channels were selected based on availability. The literature survey inidicated a number of ubiquity dimensions that could be measured individually. Market research was conducted and values assigned to each of the dimensions. The measurements were based on the percentage of subscribers that could be reached with each of the technologies. Furthermore the measurements were done in three different countries to provide a global picture. Results were graphed and compared. In conclusion it was determined that SMS and IVR are the most ubiquitous access channel, which makes it a safe choice for applications where the number of subscribers that is reached influences the success of the application.

Keywords: Ubiquity, communication technologies, access channels, mobile application

1. Introduction

One of the characteristics of mobile access channels identified in previous research is *ubiquity*. It has been named as a characteristic that needs to be measured in order to determine the most appropriate access channel for a mobile application. This paper addresses the problem of measuring the ubiquity of a number of access channels in order to rank them accordingly.

A literature survey was conducted to identify the access channels that should be measured. Furthermore, the literature survey was used to break down ubiquity into a number of dimensions that could be measured individually. These dimensions together form a total ubiquity measurement.

The methodology involved market research to determine values for each of the identified dimensions. This process was based on public-domain information that is readily available. In some cases however, information was not available in the public domain and a questionnaire was sent to role players in the industry to obtain the information. This was only necessary in a limited number of cases. Each one of the dimensions was measured as a percentage of number of mobile subscribers that could be reached through a specific access channel. These values were then summed and reworked to a total ubiquity percentage.

1.1. Definitions

The following terms are used in this paper:

Mobile Access Channel / Access Channel / Channel: user-interface technology that is used to enable the user to interact with the back-end server.

Mobile Applications: "… applications that execute on mobile devices using a cellular network for communications" (Schwenke & Weideman, 2007).

Mobile Banking / M-Banking: the process of conducting financial transactions by means of a mobile application.

Mobile Device / Handset / Phone: the device that execute mobile applications, e.g. a cellular phone.

Ubiquity: the availability of a specific technology (for the purpose of this research, an access channel) to the subscribers in a specific environment (Schwenke & Weideman, 2007).

2. Literature survey

2.1. Mobile access channels

There are a number of technologies available through which a user can access a back-end server from his/her mobile device. Not all of them are equally suitable for all applications and this produced one of the most pressing questions in the mobile applications industry: which access channel should be supported by an application? In order to answer this question, one would have to find a way to measure characteristics of each access channel and deduce an answer from the measured data (Schwenke & Weideman, 2007).

These authors identified 11 different possible access channels. They are:

- BREW (Binary Runtime Environment for Wireless),
- Cell Broadcast,
- I-Mode,
- Java (J2ME),

- MExE (Mobile Execution Environment),
- SAT (SIM Application Toolkit),
- SMS (Short Message Service),
- WAP (Wireless Application Protocol) / XHTML,
- WEB Clipping,
- WIG (Wireless Internet Gateway) and
- USSD (Unstructured Supplementary Service Data).

According to Corkrey & Parkinson (2002), Interactive Voice Response (IVR) can be used to communicate to back-end servers and this would then also qualify as an access channel. The list above was therefore extended to include IVR.

2.2. Characteristics

As stated previously, in order to find a proper answer to the research question, it is necessary to measure each of the access channels individually. One would therefore need to identify characteristics that are measurable and comparable. Four of these characteristics were identified as contributing factors towards a measurement that could support an outcome to the question. They are:

- cost,
- security,
- ubiquity and
- usability.

A complete measurement would include values for all four of these factors, (Schwenke & Weideman, 2007).

2.2.1 Ubiquity

Ubiquity involves the delivery of services in the physical world. *Where* and *when* the technology exists are factors that need to be taken into account (Scholtz & Richter, 2001).

FinMark Trust (2007) lists many of the access channels and indicates that they have different levels of ubiquity, amongst other characteristics.

Ling (2008) supports this, and indicated that ubiquity is one of the most important factors that would influence a potential application provider's choice of access channel. This is especially true in a developing marketplace where traditional banking solutions are limited. Ubiquity was also one of the characteristics defined by Schwenke & Weideman (2007) that should be measured in order to support a decision makers' choice about support of access channels.

Tadesse & Kiddan (2005) indicated that one of the advantages of m-payment systems over traditional payment systems is its ubiquity. Van der Merwe (2003) also indicated *ubiquity* as one of the advantages of m-commerce. Ayo et al (2007) list ubiquity as the most favoured reason for users to use mobile banking.

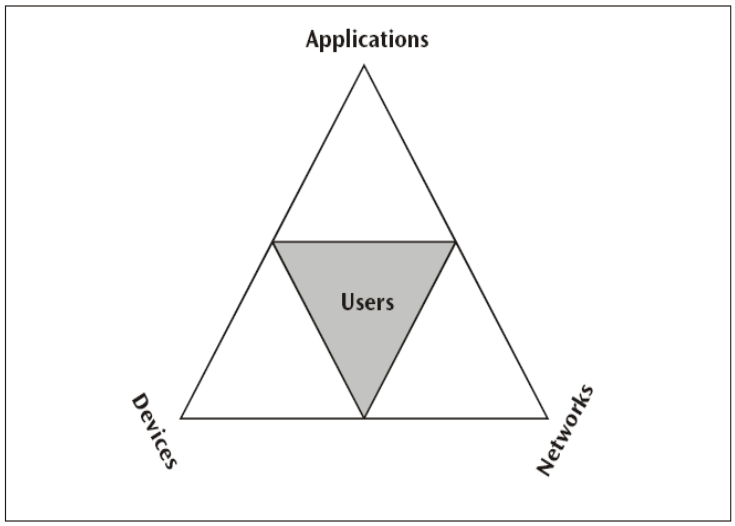
2.3. Factors that influence ubiquity

Hellmund (2003) identified three factors that have a strong influence on each other in the mobile applications environment. These are:

- application providers,
- device manufacturers and
- Mobile Network Operators (MNOs).

Together these factors also have a strong influence on the ubiquity of a specific mobile access channel. Figure 1 shows that the user is influenced primarily by this trio of role players.

Figure 1: Factors influencing the ubiquity of a channel. Source: Hellmund (2003)



Ling (2008) refined this view and identified the following four dimensions of ubiquity that could be measured individually:

- handset support,
- MNO support,
- SIM Card support and
- technology support.

As seen in Figure 1, the users are central to the ubiquity of the access channel. Therefore, any measurement of ubiquity should indicate the relative percentage of users that can be reached through a specific access channel (Pousttchi, 2004). This view is supported by Derballa & Pousttchi (2004) when they indicate that the reachability of users is an important aspect of ubiquity. This is further strengthened by Pau (2004) who identified ubiquity and *user access* as being the two major differences between normal Internet-banking and mobile-banking.

Pousttchi & Turowski (2002) identified an advantage of mobile banking as the user being able to transact real-time, any time, anywhere and with any device. For the

purpose of this research, *anywhere* can be translated to *any MNO,* and *any device* can be translated to *any handset and any SIM card*.

2.4. Handset Support

Handset support can also be defined as the availability of a specific technology on available mobile devices. Oliver & Barett (2004) indicate that compatibility issues among different handsets limit the potential for upgrade and expansion of mobile devices much more than that of traditional PCs. This is mainly because of a lack of proper standards. Chovanova (2006) indicates that the technology is dependent on support by the mobile device.

2.5. MNO Support

Subscribers have joined a specific mobile network. It is therefore obvious that MNO support for a specific access channel will have a large influence on the availability of that channel to users.

Pousttchi (2004) reports that banks (financial institutions) and MNOs are often in competition with one another. Both of them want to "own" the customer and in a mobile banking environment this hinders the ubiquity of the application. This is caused by the fact that the financial institution is required to have special agreements with the MNO before the MNO will allow transacting.

2.6. SIM Card Support

Some access channels (SAT & WIG) are applications that execute on the SIM card (Schwenke & Weideman, 2007). It would therefore be crucial to determine whether or not the SIM card has the ability to support a specific access channel before it can be decided to supply that channel to users.

This view is supported by Chovanova (2006), which further indicates that a user will have to buy a special SIM card to use the SIM card based applications.

2.7. Technology Support

In some cases, the access channel is regularly available on the MNO, SIM card and even the handset, but the underlying technology to use the channel is not available (Ling, 2008). An example of this situation is the USSD channel, which is available on all GSM networks, all handsets and all SIM cards, but it requires a USSD gateway between the MNO and the back-end application. The availability of these gateways may be problematic and in turn define the access channel as irrelevant for a specific market.

With the introduction of 2.5G networks, the MNOs had to acquire the ability to charge their customers for the new services that the technology provided. This is an indication that technology plays an important role in the ubiquity aspect of mobile applications (Pousttchi, 2004).

3. Methodology

In order to measure the ubiquity of a mobile access channel, the authors chose to do market research within South Africa, the UK (representing a country with a higher GDP than South Africa) and Kenya (representing a country with a lower GDP than South Africa).

Furthermore, the measurements were based on the percentage of prospective users that can be reached with a specific access channel. This implies, therefore, that the market share of each of the available MNOs had to be taken into account for each of the measurements.

3.1. Market share of MNOs

Since the market share of each of the MNOs plays a vital role in the measurement of any ubiquity dimension, the first step would be to measure the market share of each MNO. This was then used in the rest of the measurements.

Based on information retrieved from Vodacom (2008), MTN (2008) and Coetzee (2008), the subscriber numbers for the different MNOs in South Africa are shown in Table 1.

Table 1: Market share of MNOs in South Africa

Mobile Network Operator	**Number of subscribers (in 1000 s)**	**Percentage market share**
Vodacom	24255	56.34
MTN	14799	34.37
Cell C	4000	9.29
*Virgin Mobile	?	0
Total	**43054**	**100**

Wikipedia (2008) indicated the market share of MNOs in the UK to be as listed in Table 2.

Table 2: Market share of MNOs in the UK

Mobile Network Operator	**Number of subscribers (in 1000 s)**	**Percentage market share**
O2	18382	23.34
Vodaphone	17645	22.4
T-Mobile	17311	21.98
Orange	15400	19.55
3	3900	4.95

*Virgin Mobile	4520	5.74
*Tesco Mobile	1500	1.9
*Blyk	100	0.13
*MobileWorld	?	0
*Fresh Mobile	?	0
*BT Mobile	?	0
*Dot Mobile	?	0
*ASDA Mobile	?	0
*Talk Mobile	?	0
Total	**78758**	**100**

Wikipedia (2008) indicated the market share of MNOs in Kenya to be as listed in Table 3.

Table 3: Market share of MNOs in the Kenya

Mobile Network Operator	**Number of subscribers (in 1000 s)**	**Percentage market share**
Safaricom	6500	78.72
Celtel	1757	21.28
Total	**8257**	**100**

(*) - Indicates so-called *virtual* networks that operate with one of the more established networks' technology.

(?) - Indicates values that were unknown at the time of the research.

3.2. Ubiquity dimensions

As shown earlier, there are four dimensions that influence the total ubiquity of an access channel. These are:

- device support,
- MNO support,
- SIM card support and
- technology support.

Ling (2008) indicated that the dimension that would probably have the most weight in a total ubiquity measurement, is that of handset support. It was therefore decided that *handset support* should carry a relative weight of *two* while the others all carry a relative weight of *one*. Furthermore, each dimension was measured as a percentage of subscribers that can be reached with a specific access channel. Thus a measurement

of 50% for MNO support in South Africa would indicate that 50% of all South African subscribers are using an MNO that supports a specific access channel.

3.3. Selection of access channels

The access channels were identified in Section 2.1. The original list of channels was refined to those that are readily available. Some are not available on GSM networks (e.g. BREW) and others (MExE) seems to be unavailable in a production environment. The list was therefore refined to a list that is readily available in the countries where the measurements were taken. The final list of measured access channels was:

- IVR,
- Java,
- SMS,
- WAP / XHTML,
- WIG and
- USSD.

3.4. Ubiquity values

The values assigned were gathered from various sources. They were:

- Clickatell (2008) – supplied data regarding the SMS channel,
- Flashmedia (2008), Jinny, (2008), Mark & Bang (2008) & Redknee (2008) – supplied data regarding the USSD channel and
- Comsys (2008) – supplied information regarding the IVR channel.

Various avenues were explored to gather information regarding handset specific and SIM card specific data, but the authors of this research were unable to obtain any usable data in that regard. Some assumption could be made though based on Bezuidenhout & Porteous (2008). These were:

- handsets are more likely to be WAP/XHTML enabled than Java/J2ME enabled and
- SIM cards are like to be more restrictive than handsets when ubiquity is considered.

Therefore, the following values were assumed for these two dimensions:

- 70% of handsets in use are WAP/XHTML enabled,
- 60% of handsets in use are Java/J2ME enabled,
- 50% of SIM cards in use are capable of executing a SIM card application for WIG or SAT,
- it is assumed that all MNOs in the UK have the ability to run a commercial gateway for the purposes of a SIM card based access channel.

In Kenya, the MNO support for SIM card based access channels was assumed to be 0%.

Table 4 lists the ubiquity values assigned in South Africa for each of the selected access channels.

Table 4: Summary of assigned ubiquity values in South Africa

	IVR	J2ME	SMS	USSD	WAP	WIG
Handset Support	200	120	200	200	140	200
MNO Support	100	100	100	100	100	90
SIM Card Support	100	100	100	100	100	50
Technology Support	100	100	100	99	100	90
Total	**500**	**420**	**500**	**499**	**440**	**430**
Percentage	**100**	**84**	**100**	**99.8**	**88**	**86**

Table 5 lists the ubiquity values assigned in the UK for each of the selected access channels.

Table 5: Summary of assigned ubiquity values in the UK

	IVR	J2ME	SMS	USSD	WAP	WIG
Handset Support	200	120	200	200	140	200
MNO Support	100	100	100	100	100	100
SIM Card Support	100	100	100	100	100	50
Technology Support	100	100	98	66	100	100
Total	**500**	**420**	**498**	**466**	**440**	**450**
Percentage	**100**	**84**	**99.6**	**93.2**	**88**	**90**

Table 6 describes the ubiquity values assigned in Kenya for each of the selected access channels:

Table 6: Summary of assigned ubiquity values in Kenya

	IVR	J2ME	SMS	USSD	WAP	WIG
Handset Support	200	120	200	200	140	200
MNO Support	100	100	100	100	100	0
SIM Card Support	100	100	100	100	100	50
Technology Support	100	100	100	100	100	0
Total	**500**	**420**	**500**	**500**	**440**	**250**
Percentage	**100**	**84**	**100**	**100**	**88**	**50**

The combined ubiquity measurements for the three countries are listed in Table 7.

Table 7: Summary of combined ubiquity values

	IVR	J2ME	SMS	USSD	WAP	WIG
Handset Availability	200	120	200	200	140	200
MNO Availability	100	100	100	100	100	90
SIM Card availability	100	100	100	100	100	50
Technology Availability	100	100	99	79	100	90
Total	**500**	**420**	**499**	**479**	**440**	**430**
Percentage	**100**	**84**	**99.8**	**95.8**	**88**	**86**

The *handset support* has a maximum value of 200 where all the others have a maximum value of 100. A maximum value of "*500*" could be assigned to any specific channel. As seen in the table, the total value was converted back to a single percentage that indicates the overall ubiquity of each of the access channels.

3.5. Motivation for assigned values

Below follows the motivation for each of the assigned values on a per channel basis.

3.5.1. IVR

IVR is based on voice calls. Since voice calls is the primary function of a mobile phone, a value of 100% is assigned for handset support. This is the same for all countries measured in this research.

Similarly, the primary function of a MNO is to allow subscribers to make voice calls. A value of 100% can therefore be assigned for MNO support. The same value applies to all countries measured in this research.

SIM cards generally do not play a role in voice calls. The only function of the SIM card is to set up the connection to the MNO. After that the voice call is completely handled by the device. A value of 100% can therefore be assigned to SIM card support. This is applicable to all countries where the measurements were taken.

The only possible problem with IVR as a mobile access channel is the availability of an IVR server. This should typically be provided by the application provider (in the case of mobile banking, the financial institution). Depending on the specific needs of the application, these IVR servers may be rather expensive, but they are easily available in commercial and open source format. Since the MNO has no involvement in the setup of such an IVR server, the application provider can implement any available server. In all three regions it was found that there are some 3rd party provider of a hosted IVR service. A value of 100% could therefore be assigned to all three the regions.

3.5.2. J2ME

Not all handsets support Java applications. As indicated by Bezuidenhoudt & Porteous (2008) only *advanced* handsets support Java applications. Due to limitations, it was not possible to obtain data that indicate the number of handsets in use that supports Java.

When a Java application is used as an access channel, it will generally make use of GPRS as a bearer channel. GPRS is supported by all GSM networks and is therefore regarded as completely independent of mobile network.

Java applications on mobile devices are generally not dependent on specific SIM cards. The application is stored and run on the device. Therefore, SIM card support can be regarded as 100%.

Since all GSM networks support at least GPRS communication, the availability of the technology is regarded to be 100%.

3.5.3. SMS

All handsets (standard and advanced according to the definition of Bezuidenhoudt & Porteous (2008)) support text messaging or SMS. A rating of 100% is therefore assigned to the handset availability of this technology.

All GSM networks support SMS messages. SMS can therefore be regarded as completely independent of the MNO. A rating of 100% is therefore assigned for MNO independence.

Since SMS messages are available on the handset irrespective of the SIM card in use, a rating 100% is assigned to SIM card availability for SMS.

The SMS technology is dependent on some sort of gateway between the MNO and the back-end application. These gateways may be owned by the MNO or by a third party. Often a bulk-SMS provider can be used for this purpose, but this may not always be available. Since the measurements were done in South Africa, and a bulk-SMS provider is available to all networks, a rating of 100% can be assigned for this dimension of SMS. In the UK a bulk provider that services 98% of the subscriber base was found and in Kenya 100% of subscribers can be reached via a bulk-SMS provider. This yields a combined value of 99% through the 3 measured regions.

3.5.4. USSD

All GSM handsets support USSD communication. Since the technology is not based on any special application, but merely on a text-message (similar to SMS) type of technology, a valuation of 100% is assigned to handset availability for USSD.

All GSM networks support USSD communication. It is part of the basic GSM technology that is implemented to allow voice communication. A valuation of 100% can therefore be assigned to the MNO independence of USSD. Since USSD communications is a function of the handset and not of the SIM card, SIM card compatibility is regarded as 100% for USSD.

USSD requires a gateway to be installed between the back-end application and the MNO. These gateways are commercially available and can be bought. It was however

discovered that 99% of subscribers in South Africa, 99% in the UK and 100% in Kenya can be used with commercial USSD gateways that are currently in use.

3.5.5. WAP / XHTML

WAP browsers are not available on all handsets. According to Bezuidenhoudt & Porteous (2008) it is only available on (what they call) advanced handsets. Due to the unavailability of data, an accurate measurement for this could not be obtained.

Since WAP uses GPRS as a bearer channel and GPRS is supported by all GSM networks, a rating of 100% can be assigned to the MNO independence dimension for WAP.

WAP does not make use or require any special functionality on a SIM card. It is therefore regarded as being supported by all available SIM cards and a rating of 100% is assigned for this dimension of WAP.

Since the GSM networks support GPRS communication, it implies that they also have the technology to forward internet communications to a Internet backbone. A valuation of 100% is therefore assigned for this dimension of WAP. This is true for all countries where measurements were taken.

3.5.6. WIG

According to Bezuidenhoudt & Porteous (2008) SIM card applications only require a standard handset. It is therefore regarded as being supported by all handsets and a valuation of 100% is assigned to this dimension of WIG.

SIM card applications a highly dependent on support from the MNO. Since the MNO is required to put the application on the SIM card and they are often also involved in adding security keys onto the SIM card, this can be regarded as a 100% dependence on the MNO. In South Africa, two of the four MNOs have the availability to support WIG applications. However, these two MNOs have the majority market share in the South African marketplace, according to recent reports (Vodacom, 2008 & MTN 2008, Coetzee, 2008) and therefore a value of 90% was assigned to MNO availability for WIG within South Africa. Due to data not being available, an accurate measurement for this was not possible.

The majority of subscribers can be reached with WIG, since the major MNOs in South Africa support it. Not all SIM cards currently in use by these subscribers have the ability to execute a WIG application. No data could be found during this project to accurately indicate which percentage of SIM cards in use, can support such applications.

GSM networks that support WIG technology, will also have the ability to send the data received from the handset to the external application. Therefore the valuation of available technology and the MNO is similar in this regard and the same value is assigned.

4. Analysis

Figures 2, 3 and 4 show the assignment of ubiquity measurements assigned in South Africa, the UK and Kenya respectively. It is clear from the graphs that SMS and IVR have the highest total ubiquity with IVR and USSD shortly behind it. The limitations on MNO and SIM cards have a negative impact on WIG, while WAP and J2ME are limited by handset support.

Figure 2: Ubiquity measurements in South Africa

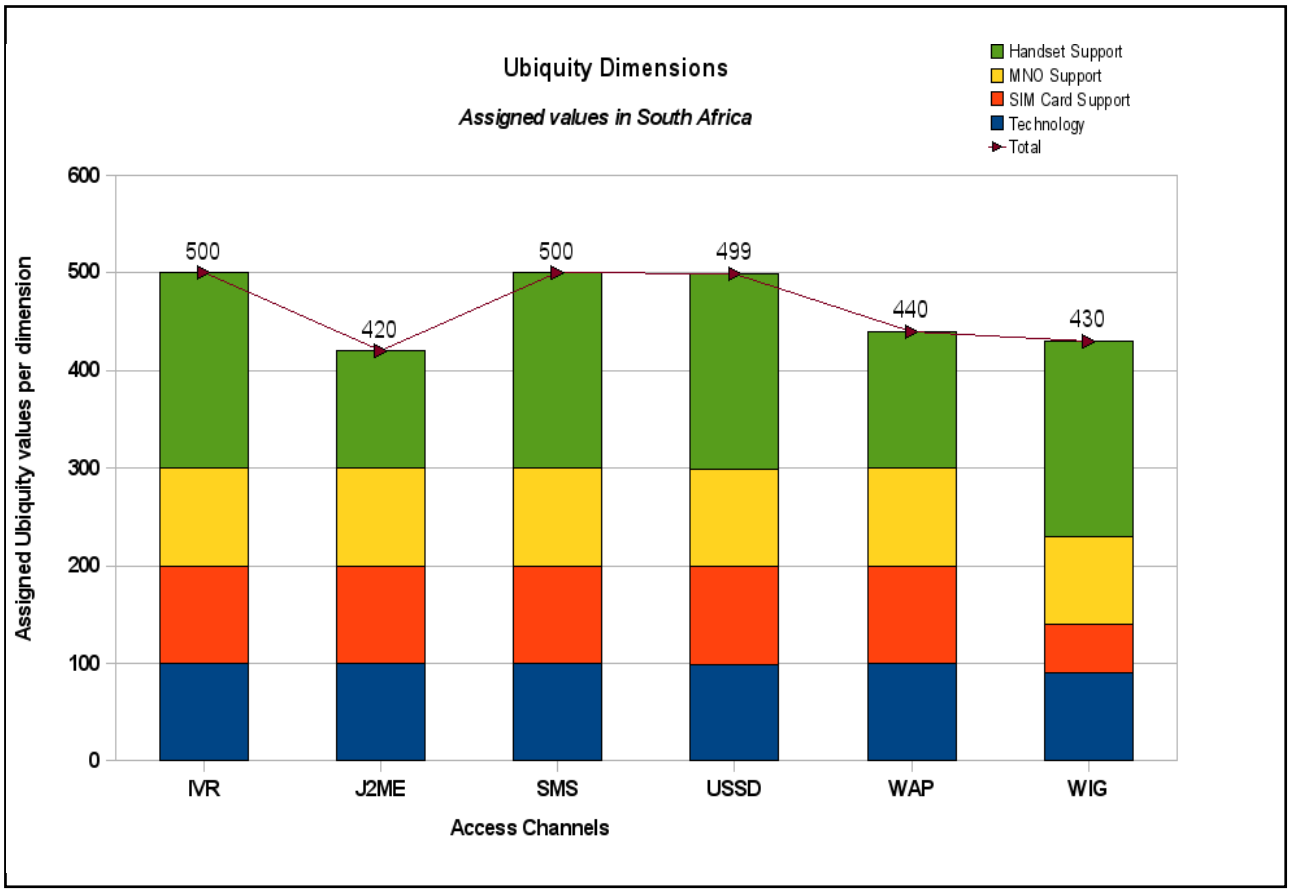
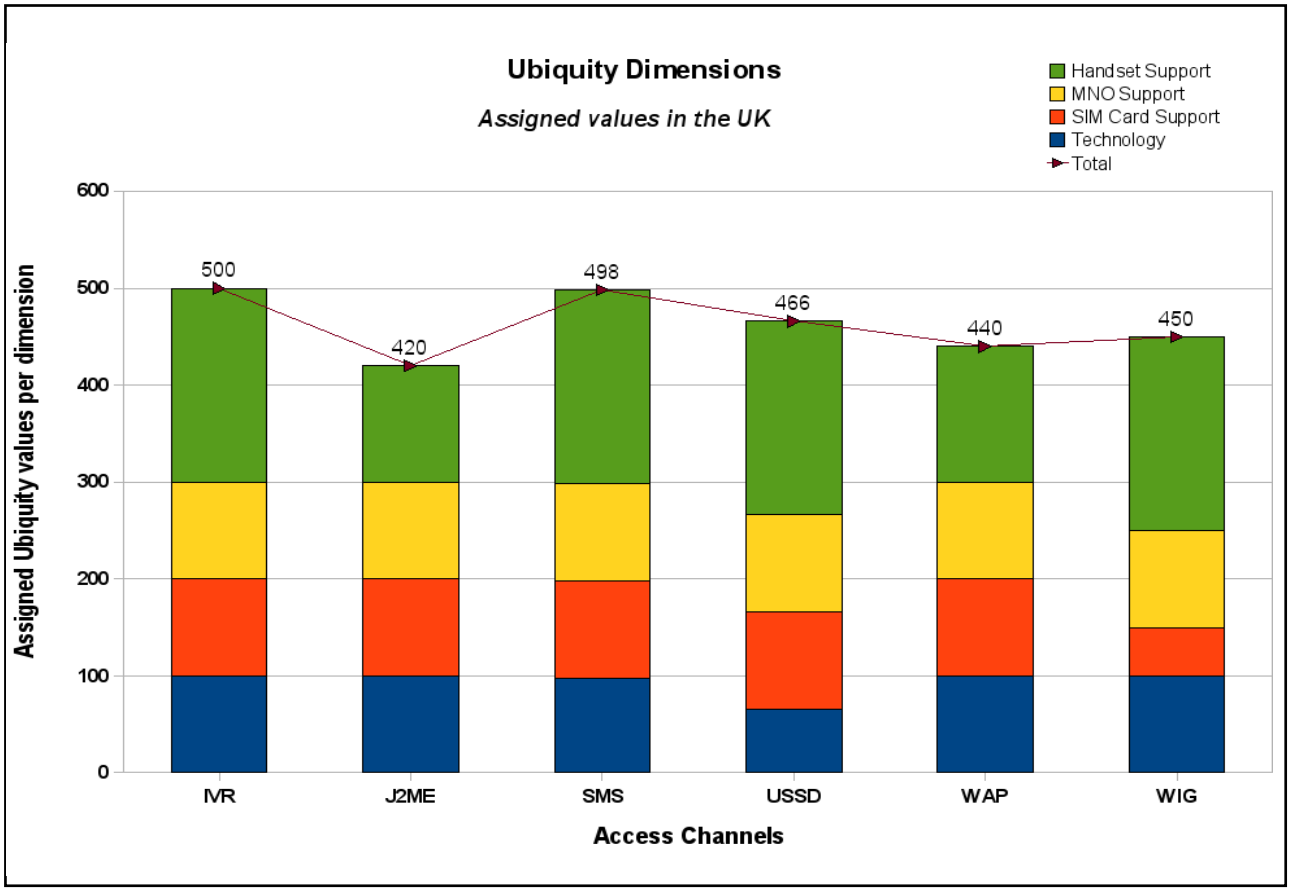


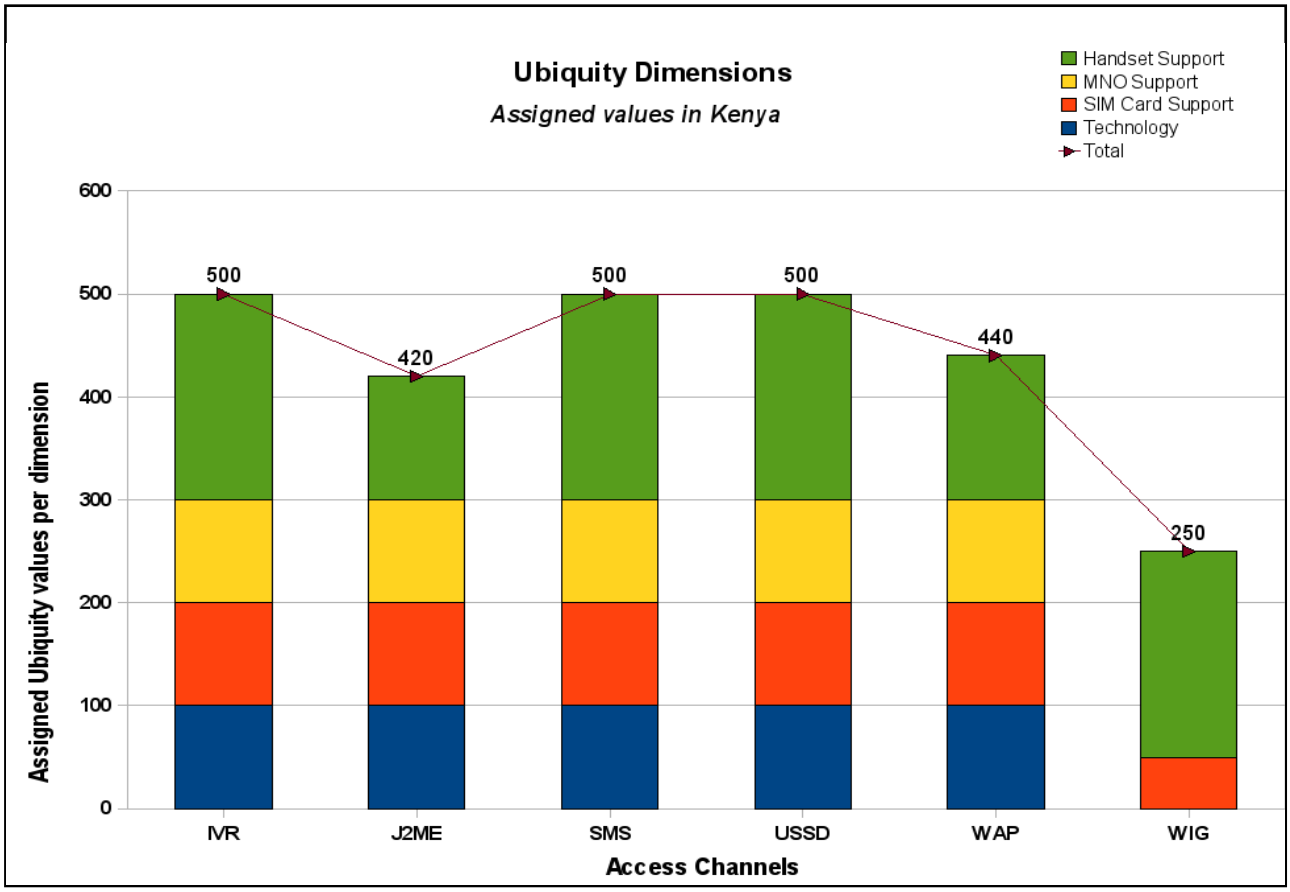
Figure 2 shows the ubiquity of the access channels in South Africa. It is of interest to note that IVR, SMS and USSD have almost identical values. The other three access channels are all negatively influenced by MNO and SIM card support (WIG), and handset support (WAP and J2ME).

Figure 3: Ubiquity measurements in the UK



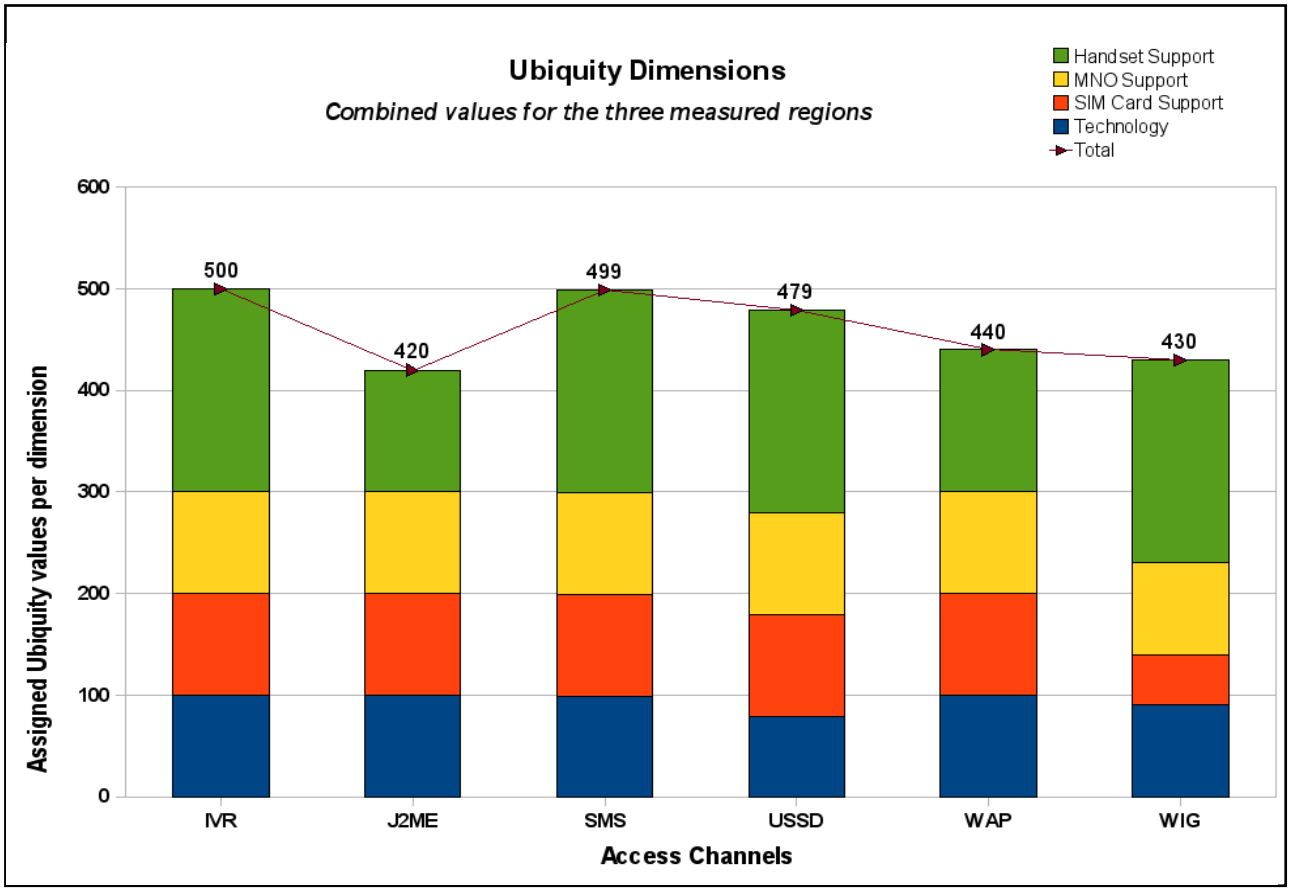
The UK ubiquity of the access channels is similar to that of South Africa. The main difference is in the figure for the USSD channel, which is notably lower in the UK than in South Africa.

Figure 4: Ubiquity measurements in Kenya



Kenya's ubiquity measurements again differ from those of the previous two countries. While USSD is higher than in the UK, WIG is notably lower than in any of the other two regions. This is due to the lack of technology, SIM card and MNO support.

Figure 5: Combined Ubiquity measurements



4.1. Handset support

It is significant to note that handset support is similar for four of the access channels. The other two are significantly hampered by their lack in this area. Since handset support carries double the weight of any of the other dimensions, it means that the impact of a lack of handset support is even greater.

4.2. MNO support

The only access channel suffering as a result of a lack of MNO support is the WIG channel. This does however have an impact on the ubiquity of such a channel, since it also has an influence on SIM card support as well as technology support. It is also of interest to note that even though only two of the four MNOs in South Africa support WIG, their market share enables this to have a great impact on the overall ubiquity.

4.3. SIM card support

SIM card support is greatly influenced by MNO support. This is because the SIM cards are owned by the MNO. The MNO would therefore dictate whether or not the SIM cards will support an application. Furthermore, even if a MNO does support a SIM card dependent channel, the SIM cards that are currently used by subscribers may not. There may be a significant cost and administration impact to upgrade all subscribers to supported SIM cards, and that may also not be cost effective.

4.4. Technology support

Technology support is one of the more interesting but difficult dimensions to measure. The reason is that the technology for all the access channels is available, but it may not be properly implemented, or may not be implemented at all. The implementation of such technology may again have a significant cost implication on either the MNO or the financial service provider. Another factor of technology (even though not in South Africa) is the fact that GSM protocols may not have been implemented properly in all GSM networks. This may cause a channel to be unusable until the protocols are implemented, which in turn may have a cost implication on the MNO.

The values that were assigned for technology support were based on the immediate (with no extra installation costs) availability of the technology to forward communications received via the specific access channel to a back-end server. In some cases (like SMS) the technology may not belong to the MNO, but a third-party provider exists for such technology. This would be regarded as technology available to all MNOs.

5. Conclusion

Ubiquity measurements were done in three regions; South Africa, Kenya and the UK. The intention was to gather data in the three different regions to get a more universal measurement.

These measurements were calculated as a percentage of mobile users that can be reached through a specific access channel. In order to determine a proper ubiquity measurement, the following four factors were considered:

- technology support,
- SIM card support,
- MNO support and
- handset support.

As indicated by Ling (2008) the handset support was measured and multiplied to double the weight of the other factors.

It is important to note that the measurements were done independently of any other factors that may influence a decision on whether or not to support a specific channel. E.g. the SIM card measurement was taken purely based on whether it is possible to load an application onto the SIM card. The fact that the SIM card may or may not already contain security keys that may be required by a banking application, was not considered at all.

After the measurements were complete, it became clear that there is not much difference in the ubiquity of the different channels. There are however differences that may influence a decision on whether or not to support a specific access channel.

The following conclusions (purely based on ubiquity) were drawn.

- IVR is the most ubiquitous access channel.
- SMS is almost identical to IVR and if more data were available, it could be

proven to be identical.

- USSD is slightly less ubiquitous, mainly due to the fact that commercial USSD gateways are not available to all MNOs. There are, however, a number of providers to USSD gateways and if the application provider has the money to spend, they can even implement their own gateway. This could eliminate the difference between IVR/SMS and USSD completely.
- The Java/J2ME channel has the lowest ubiquity, because of the limited handset support. This limitation is overcome by the fact that the latest handset models mostly have Java support and as they become cheaper, the ubiquity of this channel will increase.
- WAP (similar to J2ME) is hindered by limited handset support. However, there are more support for WAP than Java, which gives it a higher rating.
- WIG/SAT are limited not only by SIM card support, but also by MNO support.

In conclusion, it should be noted that ubiquity is only one of a number of characteristics that could be measured. Therefore, application providers should carefully consider the measurements of other characteristics as well, when they decide which access channels they should support. It is the opinion of the authors that some application providers, e.g. providers of competition lines, should use the SMS access channel. Others, e.g. mobile banking application providers, should consider security and usability measurements as well before decisions are made as to the most appropriate access channel for their applications.

6. Further research

As shown by Schwenke & Weideman (2007), ubiquity is not the only characteristic that should be measured to find the most appropriate access channel for an application. More research is needed to measure the other characteristics as well.

The authors of this research suggest the following possible areas of related research:

- measurement of the security characteristic,
- measurement of the usability characteristic,
- measurement of the cost characteristic and
- wider scope research of the ubiquity characteristic to determine global ubiquity as opposed to only the three countries of this study.

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