Enhancing the Use of the Mobile Infrastructure in Cameroon

The Case of Bayam Sellam

PhD Thesis

Dipl.-Inf. Paul Dayang
18.11.2013

Fachbereich Mathematik / Informatik
Studiengang Informatik

1. Supervisor: Prof. Dr. Karl-Heinz Rödiger
2. Supervisor: Prof. Dr. Frieder Nake

Acknowledgements

While completing this PhD Thesis, I have benefited from the love and support of many people in different ways, through advice, both technical and personal, encouragement and patience. Now, I would like to express my deep-felt gratitude to my parents and the following persons:

Dané Djouwa Dayang, Gaywa Dague Dayang, Hélène-Laure Dayang, André Djonga, Christelle Dimegni Ndjouwa, Sidoine Ghomsi, Berthold Hoffmann, Kolyang, Mbere Koué, Victor Koué, Frieder Nake, Michèle-Laure Watat épse Nouga, Rose Maïtchie, Justin Man-Igri, Oscar Mourbare, Karl-Heinz Rödiger, Rebecca Siafaka.

Abstract

The expansion and the reliability of mobile technology in Sub-Sahara Africa - as well as elsewhere - opened up diverse opportunities. For instance, the access to learning material, conduction of commercial activities, promotion of agricultural activities, enhancement of governmental transparency, support of healthcare practices, etc. To harness the existing mobile infrastructure, diverse users are looking for effective and efficient ways, for instance, the *Bayam Sellam* in Cameroon. Bayam Sellam refers to people engaged in trade between rural and urban markets.

This work analyses the usage and development of information and communication technology in Sub-Sahara Africa in general, and the mobile technology and its constraints in particular. An efficient use of the mobile technology depends on appropriate mobile services and applications. These should produce and use local digital content, so as to enhance the use of the existing mobile infrastructure and contribute to satisfy the user's needs.

As a case study, we deal with a tailored mobile commerce solution for Bayam Sellam and other related stakeholders such as the governmental department for price regulation. The arising question is how Bayam Sellam can use the mobile devices to improve their business activities and, thereby, use the mobile infrastructure more efficiently. With a questionnaire, we investigate the wishes of 250 Bayam Sellam in Ngaoundéré. The aim was to develop a tailored mobile commerce solution called Bayasella for Bayam Sellam. The solution is a hybrid application based on the approach of local data storage, web technologies and frameworks (HTML5, PhoneGap, etc.). Bayasella stores product details offline, and synchronises them with the online database whenever the user wants. The online activities (up/downloading offers) shall be very short so as to minimise charges.

Another key issue is: if the provided architecture can be applied to other domains. We put our attention on a combined mobile weather application that impacts the mobile technology and the Bayam Sellam business activities. For this purpose, we combine endogenous qualitative weather data - from ethnic group Tpuri - with existing quantifiable data from established weather forecasting systems, such as World Weather Online.

Zusammenfassung

Die zunehmende Ausbreitung und Zuverlässigkeit mobiler Technologien eröffnet in Afrika südlich der Sahara - wie auch anderswo - vielfältige Möglichkeiten: den Zugang zu Lernmaterialien, die Durchführung geschäftlicher Tätigkeiten, die Förderung landwirtschaftlicher Tätigkeiten, die Erhöhung der Transparenz in der öffentlichen Verwaltung, die Unterstützung im Gesundheitswesen usw. Um die bestehende Mobilfunk-Infrastruktur zu nutzen, suchen diverse Benutzer nach effektiven und effizienten Wegen, zum Beispiel die *Bayam Sellam* in Kamerun. Bayam Sellam bezeichnet Personen, die Handel zwischen ländlichen und städtischen Märkten ausüben.

Diese Arbeit analysiert die Nutzung und die Entwicklung der Informations- und Kommunikationstechnologie in Sub-Sahara Afrika im Allgemeinen, und mobile Technologien und ihre Einschränkungen im Besonderen. Eine effiziente Nutzung der zugrunde liegenden Infrastruktur setzt geeignete mobile Dienste und Anwendungen voraus. Diese sollten lokale digitale Inhalte produzieren und nutzen können, um so die Nutzung der vorhandenen mobilen Infrastruktur zu verbessern und den Ansprüchen lokaler NutzerInnen gerecht zu werden.

Als Fallstudie beschäftigen wir uns mit einer maßgeschneiderten Lösung von *mobile commerce* für Bayam Sellam und andere beteiligte Akteure wie die Regierungsabteilung für Preisregulierung. Hier stellt sich die Frage, wie Bayam Sellam die mobile Geräte einsetzen können, um ihre geschäftlichen Tätigkeiten zu verbessern und dadurch die mobile Infrastruktur effizienter zu nutzen. Mit einem Fragebogen ermittelten wir die Wünsche von 250 Bayam Sellam in Ngaoundéré. Das Ziel war, eine bedarfsgerechte mobile Anwendung namens Bayasella für Bayam Sellam zu entwickeln. Als Lösung wurde eine Hybridapplikation entwickelt, basierend auf der Technik der lokalen Datenspeicherung (local data storage), auf Web-Technologien und -Frameworks (HTML5, Phone-Gap, etc.). Bayasella speichert Produktdetails offline, und synchronisiert sie mit der Online-Datenbank, wenn die BenutzerIn es wünscht. Dabei sollen die Online-Aktivitäten (Herunter- und Hochladen von Angeboten) möglichst kurz sein, um die Gebühren zu minimieren.

Ein weiteres Thema ist, ob die bereitgestellte Architektur auf andere Anwendungsfälle übertragbar ist. Wir befassen uns mit einer kombinierten mobilen Anwendung für Wetter, die die Mobilfunknutzung und Geschäftstätigkeiten der Bayam Sellam beeinflusst. Dafür kombinieren wir endogene und qualitative Wetterdaten - der ethnischen Gruppe Tpuri - mit bestehenden quantifizierbaren Daten von etablierten Wettervorhersage-Systemen, am Beispiel von World Weather Online.

Contents

List of Figures **ix**

List of Tables **x**

1 Introduction **1**

1.1 Hypothesis Statement 4

1.2 Motivation 4

1.3 Limitation of this Work 6

1.4 Thesis Outline 6

2 Usage and Development of Information and Communications Technologies **9**

2.1 ICT Facts according to ITU 9

2.2 Findings of the Research ICT Africa 12

2.3 Resulting Facts: Communication and Information Devices 14

2.4 Mobile Telecommunication in Cameroon 15

2.4.1 Socio-Economic and cultural Environment 15

2.4.2 Actors in the Mobile Ecosystem 18

2.4.3 Market Share and Structure 18

2.4.4 Computers as Communication Medium 23

2.4.5 Regulatory and Institutional Frameworks 23

2.4.6 Ambivalent Estimates of Mobile Services vs. Economic Growth 26

2.5 ICTs in Rural and Suburb Communities 27

2.6 Constraints as Bottlenecks of Mobile Telecommunications Penetration . 28

2.6.1 Technical Constraints 29

2.6.2 Infrastructural Constraints 29

2.6.3 Social Constraints 29

2.6.4 Cultural Constraints 30

2.6.5 Skill Constraints 30

3 Mobile Commerce in Perspective **31**

3.1 Defining Mobile Commerce 31
3.2 Trends and Type of Mobile Applications 31
3.2.1 Native Apps 33
3.2.2 Web Apps 35
3.2.3 Hybrid Apps 35
3.2.4 Other Mobile Applications 36
3.3 Mobile Commerce in Sub-Saharan African Region 36
3.4 Types of M-Commerce 37
3.5 Financial Web Sites and Applications 38
3.5.1 Web Sites 38
3.5.2 Banking 39
3.5.3 Marketing and Advertising 40
3.5.4 Manufacturing 42
3.6 Advantages of Mobile Commerce 42
3.6.1 Reducing Costs 42
3.6.2 Speeding the Flow of Goods and Information 42
3.6.3 Increasing Accuracy 43
3.6.4 Improving Customer Service 43
3.7 General Issues of M-Commerce 43
3.7.1 Security 43
3.7.2 Theft of Intellectual Property 43
3.7.3 Fraudulent Practices 44
3.7.4 Online Profiling 44
3.7.5 Collecting Sales Taxes 45
3.7.6 Legal Jurisdiction in Cameroon 45
3.8 Required Infrastructure 46

4 Stakeholders and Requirements Engineering 47
4.1 Stakeholders 47
4.1.1 Buyers and Sellers (Bayam Sellam) 48
4.1.2 Governmental Department for Price Regulation 50
4.1.3 Mobile Operators 50
4.1.4 Internet Service Providers 50

4.2 Requirements Elicitation 50
4.3 Data Analysis and Interpretation 52
4.4 Vision of a M-Commerce Application 55
4.4.1 Motivations for Bayasella as a Hybrid App 57
4.4.2 Influence Factors 57
4.5 Bayasella Requirements 58
4.5.1 Use Cases 58
4.5.2 Functional and non-functional Requirements 62
4.6 Data Model of Bayasella 64

5 Architecture, Technical Approach and Portability 66
5.1 Bayasella Architecture 66
5.1.1 Architecture based on GSM Network 66
5.1.2 Architecture based on Internet Network 69
5.1.3 Mobile Information Architecture 72
5.2 Approaches of local Storage 75
5.2.1 Historical Background 75
5.2.2 Session and Cookies 76
5.2.3 Web or HTML5 Storage 76
5.2.4 Web SQL Database 78
5.2.5 HTML5 Browser Support 79
5.3 Data Serialization 80
5.4 Global Issues of Local Data Storage for Mobiles 80
5.4.1 Malicious Attacks 80
5.4.2 Performance 81
5.5 Portability of the provided Approach 81
5.5.1 State of Weather Prediction in Cameroon 81
5.5.2 Native Weather Forecast Techniques: Case of Tpuri 83
5.5.3 Weather Forecast APIs 84

6 Implementation and Interfaces 90
6.1 Tools and Languages 90
6.1.1 Eclipse and Required Plugins 91

6.1.2 PhoneGap as a Development Framework 91
6.1.3 Communication with Remote Database 93
6.2 Code Examples of DOM or local Storage 98
6.3 User Interfaces 99
6.3.1 Start Screen 99
6.3.2 Setting Market Places and Resellers 100
6.3.3 Offer Entry Form 101
6.3.4 Offer List and Details 102
6.3.5 Synchronising and Downloading Dialogues 103
6.3.6 Downloading Form and View of Downloaded Products 104
6.4 Testing 105
6.4.1 Testing Tools for Developers 105
6.4.2 Testing by potential Users in Ngaoundéré 107

7 Conclusion and Future Work **117**

Terms and Acronyms **119**

Bibliography **121**

Appendix A Main Services of mobile Operators in Cameroon **130**

Appendix B List of important African apps **133**

Appendix C The Questionnaire **140**

List of Figures

2.1 Global ICT development from 2001 to 2013 10
2.2 Continuous growth of mobile broadband 11
2.3 African undersea cables by 2014 12
2.4 Agricultural map of Cameroon 16
2.5 Call box as a workplace 19
2.6 Phone charging as a workplace 19
2.7 CAMTEL inter-urban communication 21
2.8 MCT services 27

3.1 Predicted growth of mobile Web access acc. to Brian Fling 33

4.1 Answers acc. to Internet access via mobile 54
4.2 Product-based steps 56
4.3 Use case diagram for offline status 60
4.4 Use case diagram for online status 62
4.5 Entity model 65

5.1 Architecture based on SMS and GSM 67
5.2 Architecture based on Internet network 69
5.3 Data flow 72
5.4 Overall Bayasella information architecture 73
5.5 Android ListView 74
5.6 Android GridView 74
5.7 HTML5 technologies supported by browsers 80
5.8 Average rainfall 85
5.9 Average temperature 85
5.10 Integrated Weather API 87

6.1 Eclipse IDE 91
6.2 Hybrid architecture acc. to IBM Worklight (2011) 93
6.3 Start screen of Bayasela 100

6.4 Bayasella without offers 100
6.5 Setting market places and sellers 101
6.6 Form for entries 102
6.7 Offer details for sella 103
6.8 Offer list for sella 103
6.9 Downloading product view 104
6.10 Resynchronising a product 104
6.11 Form for product download 105
6.12 Form for product entry 105
6.13 Setting up an AVD 106
6.14 AVD 4.1.2 API Level 16 106
6.15 Browser test using Google Chrome 108

C.1 Questionnaire for eliciting Bayasella Requirements 140

List of Tables

2.1 Individual computer use, 2011 13
2.2 Mobile phone access and usage, 2011 14
2.3 Density of telecommunication means in Cameroon in 2012 19
2.4 Mobile market distribution in Cameroon, September 2012 20
2.5 Sample of communication code 22

3.1 Summary of native app development 34

4.1 Bayam Sellam survey by options and answers, 2011 53
4.2 Bayam Sellam survey acc. to investment willingness, 2011 53

5.1 Mobile vs Desktop Computer 74
5.2 Month Correspondence: Tpuri vs. English 83
5.3 Tpuri calendar for activities 84

6.1 Feature supported by PhoneGap 92
6.2 Code testing 107
6.3 Test cases for Bayasella in offline mode 111
6.4 Results for offline test cases 112
6.5 Test cases for Bayasella in online mode 114
6.6 Results for online test cases 115

A.1 Main MTN services 130
A.2 Main Orange services 131

B.1 African market of apps at a glance 139

1 Introduction

In December 2012, the Vietnam's Viettel won the third Cameroon mobile licence and thereby became the third private mobile operator in Cameroon. It thus reinforces the fact that mobile communication technology is no longer a myth in the midst of the Cameroonian society. However, the efficient use of the existing mobile infrastructure hardly depends on the number of mobile operators, but rather on locally adapted services and applications that meet the needs of users, including those with low income: this is the case of Bayam Sellam in Cameroon. Bayam Sellam refers to people involved in *buying* and *selling* activities between rural, suburb, and urban areas. In Cameroon, and in many other countries in Sub-Saharan Africa, the efficient use of wireless technology remains a challenging issue. The present work tackles this issue by focussing on a specific group of mobile users, namely the Bayam Sellam as a case study. We provide this group with a solution that improves the use of the mobile technology and we also demonstrate the applicability of the suggested architecture to another local group of users or domains.

In 2012, 49% of the phone users in Cameroon had mobile rather than land-line connections (estimated at 3%). The mobile telecommunication network is more reliable and stable. The reliability of this network infrastructure has irrefutable consequences: the number of mobile cellular subscribers is growing, new business opportunities arise, but bad practices like frauds also appear.

Despite the high cost of mobile telecommunications[1] in general, the trend is still increasing. But, Alex Twinomugisha, manager at Global e-Schools and Communities Initiative in Kenya, argues that the investment should be in software and services as well, not just cabling mobile infrastructure. Furthermore, Christian de Faria, MTN Group's Senior Vice-President for Commercial and Innovation, said:

> "*The time when operators could dictate what they offered to customers is over [...]. Operators need to go into partnerships with content providers to offer services such as cloud computing, solutions for small and medium enterprises and to provide rich content in terms of music, gaming, entertainment and news. It is no longer about selling airtime, but bundling airtime with products and services. These can range from app stores and music to value-added services like m-learning and m-health*" ([Rao 2011], p. 18).

These statements give us a window to look at what can be done with the existing infrastructure in order to offer adapted services and applications targeting to achieve specific daily tasks and, in order to improve the utility of the infrastructure.

[1] In June 2012, the Telecommunications Regulatory Board (TRB) claimed lower prices of mobile telephony from the mobile operators.

We assume that technical solutions shall be conceived of as a means of accompanying the mobile infrastructure to dispose its quality in use. This quality in use describes the degree to which the infrastructure can be used by the mobile users to meet their needs by achieving specific goals with effectiveness and efficiency, which are two usability characteristics defined in ISO 9241-11 as

> " ***3.2 effectiveness****: Accuracy and completeness with which users achieve specified goals.*
> ***3.3 efficiency****: Resources expended in relation to the accuracy and completeness with which users achieve goals*" ([ISO 9241-11 1998], p. 6).

In this work, we deal with the question *how* to develop services or applications that will allow mobile users - the case of Bayam Sellam - to use the existing infrastructure in an **efficient** manner to accomplish and perform their daily tasks **effectively**.

In fact, a report from the global telecommunications body, the International Telecommunications Union (ITU) entitled "*The world in 2011 ICT facts and figures*" indicated that by the end of 2011, the mobile phone subscriptions are estimated to six billion worldwide. In the developing world, mobile cellular penetration has reached 78.8%, while in the developed countries the mobile cellular resonance grows slowly because of market saturation. For example, according to the Federal Association for Information Technology, Telecommunications and New Media (BITKOM[2]), there were 83 million old mobile phones in Germany at the end of 2011.

In the African region, the rapid rise of mobile phone penetration reached 53% by the end of 2011, leaving, however, enough potential to grow in the next years. Considering the technological development of mobile telecommunications, people are moving rapidly from 2G to 3G, 4G, and Long Term Evolution (LTE) platforms, and hence they may take advantages of high data-transmission rates. With regard to existing infrastructure in Africa, the authors Mensah, Bahta and Mhlanga ([2010], p. 3) stated: "Infrastructure that can play an important role for businesses includes cost-efficient communication technologies such as broadband, satellite connections and Voice over Internet Protocol (VOIP)".

In Cameroon, as the rural population is estimated at over 80% of the total population, the mobile network covers up to 80% of the country as well. Stemming from the potential that the mobile technology is offering, the government has started the implementation of a community programme in the major cities of the ten administrative regions. In essence, this programme should create 2,000 telecentres by 2015 (only 115 telecentres have been created in 2013). The main objective is to provide access to telecommunication services, computer, audiovisual and Internet at a lower cost, thereby, improving the life of the population. But, since the local population has not been involved in the prior stage of this governmental policy of information and communications technology (ICT) development, the population is not properly

[2]Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e.V.

endorsing it: poor workmanship, weak security system causing telecentre burglaries, infrequent visits, etc. are common issues. These facts provide an evidence of the necessity to underline the deployment of adapted services for new media in general and mobile communication devices in particular.

In Cameroon, even rural population like livestock farmers and Bayam Sellam are mobile phone users. Bayam Sellam refers both to informal commercial activities - based largely on buying and selling - between urban and rural and the actors involved in such activities. In search of certain visibility and legitimacy, the actors have created an association called *Association des Bayam-Selam du Cameroun* (ASBY) (Association of Bayam Sellam of Cameroon) in 2004. In addition to arduous remunerative activities in which they are involved, these people struggle to use mobile phones to facilitate their work. For a Bayam Sellam, the use of mobile devices is still limited to some common core services like short calls, beep[3] or SMS.

In fact, leading web applications for electronic commerce have shown positive results in developed countries, for instance eBay - a consumer-to-consumer (C2C) corporation - or Amazon known as the world's largest online retailer. In the US, electronic commerce is expected to increase by 9% between 2012 and 2017, and online retail activities reached US$262 billion in 2013. In Cameroon, such as in many other Sub-Sahara countries analysed in this work, such entirely web-based solutions should leverage the wireless technology by considering two important constraints: low bandwidth and high cost. To handle and overcome such obstacles bound to the use of Internet, we need another approach for designing locally adapted mobile commerce (m-commerce) solutions.

Actually, we should address the question how to allow Bayam Sellam, classified as users with low-income, to effectively use Internet services provided by the existing mobile infrastructural facilities? A study entitled "**What Users Want from Mobile**", conducted by Compuware in 2011 found out that 95% of mobile users go online to search for local information with their smartphones or handheld devices [webdesignerdepot 2013]. Because mobile phones such as smartphones are cheaper that desktop computers, Bayam Sellam may use them to support their daily activities and to make use of other facilities provided by the wireless network. We conducted an interview with 250 Bayam Sellam in Ngaoundéré, Cameroon. It is worth noting that 174 (ca. 70%) of the interviewees are ready to use their mobile devices for supporting their activity, assuming they are equipped with the appropriate applications. Furthermore, 104 (41.6%) can do it via Internet if this will lead to improved outcomes. Since their activity consists of buying and selling, there is a need to develop appropriate m-commerce applications accordingly. With respect to the stakeholder's specification and the constraints of the existing infrastructure, we suggest a prototype of a tailored application for m-commerce.

Hence, this work intends to analyse and apply different technical approaches such as

[3]A service that allow mobile phone subscribers to send a free request asking the message receiver to call back. This service works for the subscriber account with no credit.

local Web storage, Web SQL Database, for the implementation of the planed app. After specifying the stakeholder and application requirements, we discuss two types of application architecture, focussing first, on the GMS network and secondly, on the Internet. The suggested m-commerce app shall operate as a hybrid application - combining native and web technology - and run mainly in offline modus. It shall use an online database aiming to synchronise the data that are processed locally, whenever an Internet connection is available. The motivation for a hybrid approach is partly argued by Oelhman and Blanc ([2011], p. 7). Concerning mobile web applications, they state:

> "*the WebKit engine powers many popular browsers like Chrome and Safari on the desktop, and mobile Safari and native Android browser in mobile (to name a few). This alone is a great reason to build web applications for mobile rather than native applications*"

Another key issue of this work is the applicability of the suggested architecture to other domains. The success of the Bayam Sellam activity may be compromised not only by weather conditions or the demanding travelling conditions between urban and rural areas, but also by the underlying farming activities, e.g., the productivity. An attention on a combined mobile weather application may again impact the mobile technology and the Bayam Sellam business activities. We therefore focus on the way the folk Tpuri endogenously describe the weather to demonstrate the portability level of the Bayasella architecture. Concisely, we combine the endogenous qualitative weather data with the existing quantifiable data from established weather forecasting systems, such as World Weather Online.

In the light of facts to be established, we state the following hypothesis.

1.1 Hypothesis Statement

The efficiency in use of the existing mobile infrastructure in Cameroon relies on specific, goal-directed and innovative technological solutions for solving local problems effectively. Solutions that may meet the need of low-income communities change and improve the use of mobile devices. Technically, the suggested approach used to develop the tailored m-commerce solution is portable and applicable to other groups of users or domains.

1.2 Motivation

First motivation
This research topic arose from my personal observations and experiences gained by running or helping to conduct some activities in the framework of the informal trade

sector. I grew up in an environment where people are involved in diverse sale activities. The trade is widely spread and serves as revenue for thousands of families. But then came the era of mobile telecommunications. Nowadays many families possess mobile devices. To address the challenging environment, it is interesting to investigate the question how these devices can support and thereby improve the sale activity, as an example of many other activities conducted by mobile phone users in diverse areas in Sub-Saharan Africa in general and in Cameroon in particular.

Second motivation
Another inducing factor is linked to my activities in IT companies, developing e-commerce solutions that support business-to-consumer and business-to-business commerce transactions. The will arose to analyse an approach that can provide a consumer-to-consumer solution adapted to the need of local populations in Cameroon.

Third motivation
The increasing number of users accessing the Internet via mobile devices is an appealing sign. In fact, nearly 450 million users worldwide accessed the Internet via mobile devices in 2009 and it is estimated that this number will exceed 1 billion in 2013 ([Stair and Reynolds 2012], p. 334). The phenomenon is similar in Cameroon.

Although all strategical questions to enhance the use of the existing mobile facilities and utilities in Cameroon may not be asked in this work, many technical motivating questions that lead our research towards the prototypical m-commerce solution can be summarised as follows:

- What kind of m-commerce should be supported through the actual mobile telecommunication, in particular in the Cameroonian context where physical market places are predominant not only for sale activities but also for meetings and many other social activities?
- How can requirements be captured and specified for the building of a hybrid application that supports a consumer-to-consumer business, in the case of Bayam Sellam?
- Which architectural design should we rely on?
- How should the architecture be built so as to be applicable to other group of users or domains, requiring less effort?
- How can the app provide cost-effective means for users who run Internet services?

1.3 Limitation of this Work

Since we might fail to satisfy some expectations of the readers, we indicate below some guidelines that summarise the limitations of this work.

This work aims to:

- analyse the use and development of ICTs in some selected countries in Sub-Saharan Africa, with an emphasis on mobile telecommunications,
- understand the mobile environment in Cameroon and identify existing constraints,
- break down the mobile commerce in relation to wireless device, the resulting advantages and some general issues as well,
- suggest an architectural approach helping to move some steps towards the improvement in use of the mobile infrastructure in Cameroon,
- check the applicability of the suggested solution to support combined weather forecasting for mobile devices, contributing to provide agricultural calendar.

Beyond the scope of this thesis are:

- improving the technical infrastructure for mobile telecommunications in Sub-Saharan countries.
- the Bayam Sellam as an informal business activity in Cameroon.
- the development of mobile applications.
- innovations of mobile telecommunications in Sub-Saharan countries.

1.4 Thesis Outline

The second chapter starts by drawing some analyses on ICT facts, and in particular some findings related to the PC and Internet penetration in ten countries in Sub-Saharan Africa. It continues by scrutinising the case of mobile telecommunication facilities, and the market share and structure in Cameroon. Next, it outlines the socio-economic and cultural environment, and the state of mobile services offered by the mobile operators carrying activities throughout the Cameroonian territory. The section dealing with regulatory and institutional frameworks presents the existing regulations and laws related to the deployment of mobile telecommunication. Afterwards, some ambivalent user opinions will be highlighted, thereby questioning the impact of the existing infrastructure. In this part of the work, related to the deployment of mobile services, we identify and describe various constraints as bottlenecks of mobile telecommunications penetration, that hinder or limit the efficient use of the existing

mobile infrastructure.

The third chapter describes m-commerce in perspective. It summarises different types of mobile applications and their trends nowadays. It underlines the impact of m-commerce in Sub-Sahara in general and in Cameroon in particular. We recapitulate the different types of m-commerce and show how the wireless devices are massively influencing the way of doing business by means of various types of mobile applications. In relation to m-commerce application, the advantages and critical issues such as security, user profiling or fraudulent practices will be analysed in order to raise the stakeholder awareness. The deployment of m-commerce service requires some components that are described at the end of this chapter.

The fourth chapter starts by defining and describing the activities of the stakeholders for which we suggest a prototypical m-commerce solution. The solution should provide subsidiaries for improving their activities by means of mobile phones. To understand the user's needs, we used a questionnaire as a research instrument and an inquiry technique. This chapter describes the inquiry process and interprets the result of data collected from the Bayam Sellam conducting sale activities in Ngaoundéré. Furthermore, this chapter contains the global vision of the application to be developed, and the associated use case diagrams that precede the list of the functional and non-functional application requirements. At the end, we suggest a Bayasella data model based on the well-established entity-relationship model.

The fifth chapter focusses on the Bayasella architecture and the technologies that intervene in the implementation process. We specify two types of architecture, the first feature is focused on GMS network, and the second on the Internet. Next, we break down some technical approaches (HTML5 technologies) for storing the application data locally. This builds the key technology underlying hybrid apps that are constructed to mainly manipulate data locally, i.e., without being bound to permanent network availability. Further, the chapter checks data serialisation and general issues such as malicious attacks, performance, which are regarded as risks associated to the use of HTML5 technologies. The end of this chapter intends to verify the applicability of the suggested approach to other areas. For this purpose, we introduce a model of a m-weather app that combines international weather forecast with traditional weather description from indigenous population, for instance, the case of the Tpuri folk.

The sixth chapter provides details on the tools and languages used, i.e., the development environment and the associated ingredients for programming. It describes how the communication with the distant database for the up/downloading process works. To render the application of HTML5 technologies more understandable, some portions of Bayasella code will be listed and explained. In this chapter, we illustrate the user

interfaces by means of some screenshots. To check the implemented functionalities and usability, several test cases have been formulated and conducted with potential users in Ngaoundére. The test results have uncovered further interesting questions. For instance, the free exchange of product data between Bayam Sellam.

The seventh chapter draws conclusions of this work. It summarises how Bayasella may impact the efficiency in use of the existing mobile infrastructure in Cameroon and how the suggested solution can be extended to other Sub-Saharan African countries in general. This concluding part gives some reasons why the user satisfaction with mobile services often depends on two important factors: mobile technology diffusion and infusion. Finally, it explores and presents possible research questions for future work.

2 Usage and Development of Information and Communications Technologies

In Sub-Saharan countries, mobile operators and governments are unilaterally investing in infrastructure either for ICT in general or for mobile telecommunications in particular. However, they neglect the development of services and applications that will enhance the efficient use of the already existing infrastructure, for instance by means of handheld devices.

First of all, this chapter provides some facts on the telecommunication technologies, some findings and statistics that stress the PC and Internet penetration in ten countries situated in Sub-Saharan Africa. Before conducting a deeper discussion on the mobile telecommunication network in Cameroon as a showcase, we present the Cameroonian socio-economic and cultural environment, followed by the description of the actors in the mobile ecosystem. Then, the next section offers an insight into the mobile telecommunications market in Cameroon by emphasising on the user-oriented services. Furthermore, the chapter highlights some ambivalent opinions of mobile users.

Finally, the last part of this chapter describes, on the one hand, the challenges of a governmental ICT policy consisting of creating multipurpose community telecentres in rural and suburb communities. On the other hand it highlights diverse constraints pointed out as bottlenecks of the development of mobile telecommunications.

2.1 ICT Facts according to ITU

While the mobile market is almost saturated in developed countries, it is ever increasing globally. Figure 2.1 shows that the development of mobile cellular telephone users is worldwide very far ahead compared to Internet users, fixed telephone lines, active mobile broadband subscribers, and fixed (wired) broadband subscribers. The uninterrupted expansion of mobile technology is due to the open market opportunities that still exist in developing countries, such as countries in Sub-Saharan Africa.

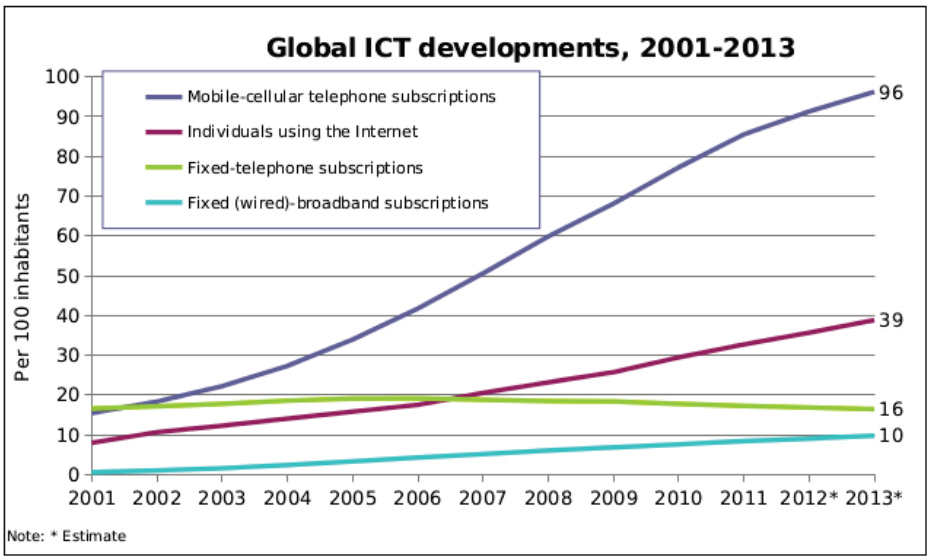


Figure 2.1: Global ICT development from 2001 to 2013
([ITU World Telecommunication/ICT Indicators database 2013])

In 2013, the mobile-cellular subscriptions (6.8 billion) are estimated to be on the threshold of the world population (7.1 billion). In developing countries, the mobile revolution is giving power to people by delivering novel ICT applications in diversified areas like education, health, government, banking, environment and business.

The map in Figure 2.2 shows the subscriptions, the penetration rate and the Compound Annual Growth Rate (CAGR) for different parts of the world. We note that Europe has the highest penetration rate (68%), followed by the Americas (48%) the Commonwealth of Independent States (CIS) (46%). Africa comes at the end, but it remains the region with the highest growth rates over the past three years, with a penetration of mobile broadband rising from 2% in 2010 to 11% in 2013.

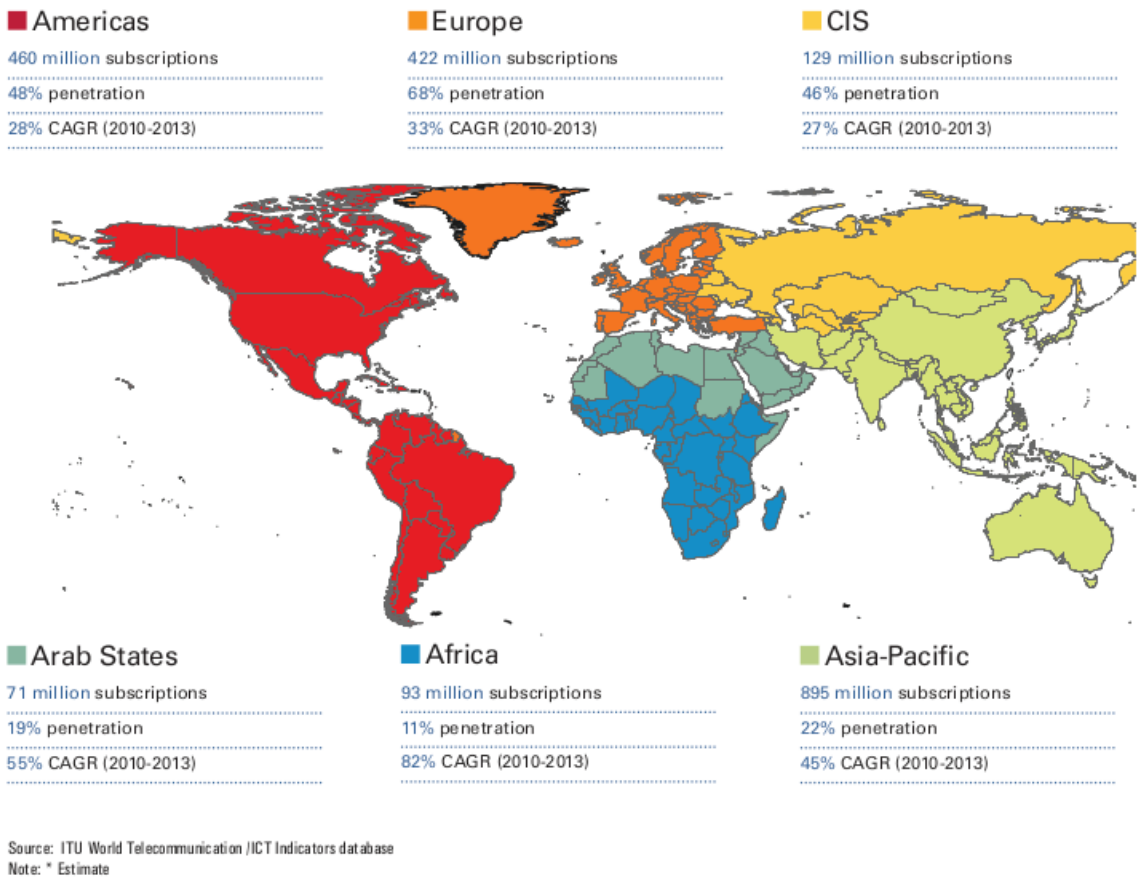


Figure 2.2: Continuous growth of mobile broadband
([ITU World Telecommunication/ICT Indicators database 2013])

Between 2010 and 2013, the CAGR of mobile broadband subscriptions has grown fastest in Africa, with an annual growth of 82%. This, despite, a significant distinction that is drawn between the cost of an entry-level mobile-broadband plan in developing countries (between 11.3 and 24.7% of monthly Gross National Income per capita (GNI p.c.)) and developed countries (between 1.2 and 2.2% of monthly GNI p.c.).

The prerequisites for a continuous ICT development in Africa are partly ensured by the African Undersea Cable (AUC). Figure 2.3 shows the overall telecommunication infrastructure on the African continent by 2014. IT highlights the active cables and those that will be functioning by 2014. Diverse mobile operators are connected to this infrastructure, for instance MTN is member of the West African Cable System (WACS) and Orange Cameroun is one of the 19 consortium signatories of the Africa Coast to Europe (ACE).

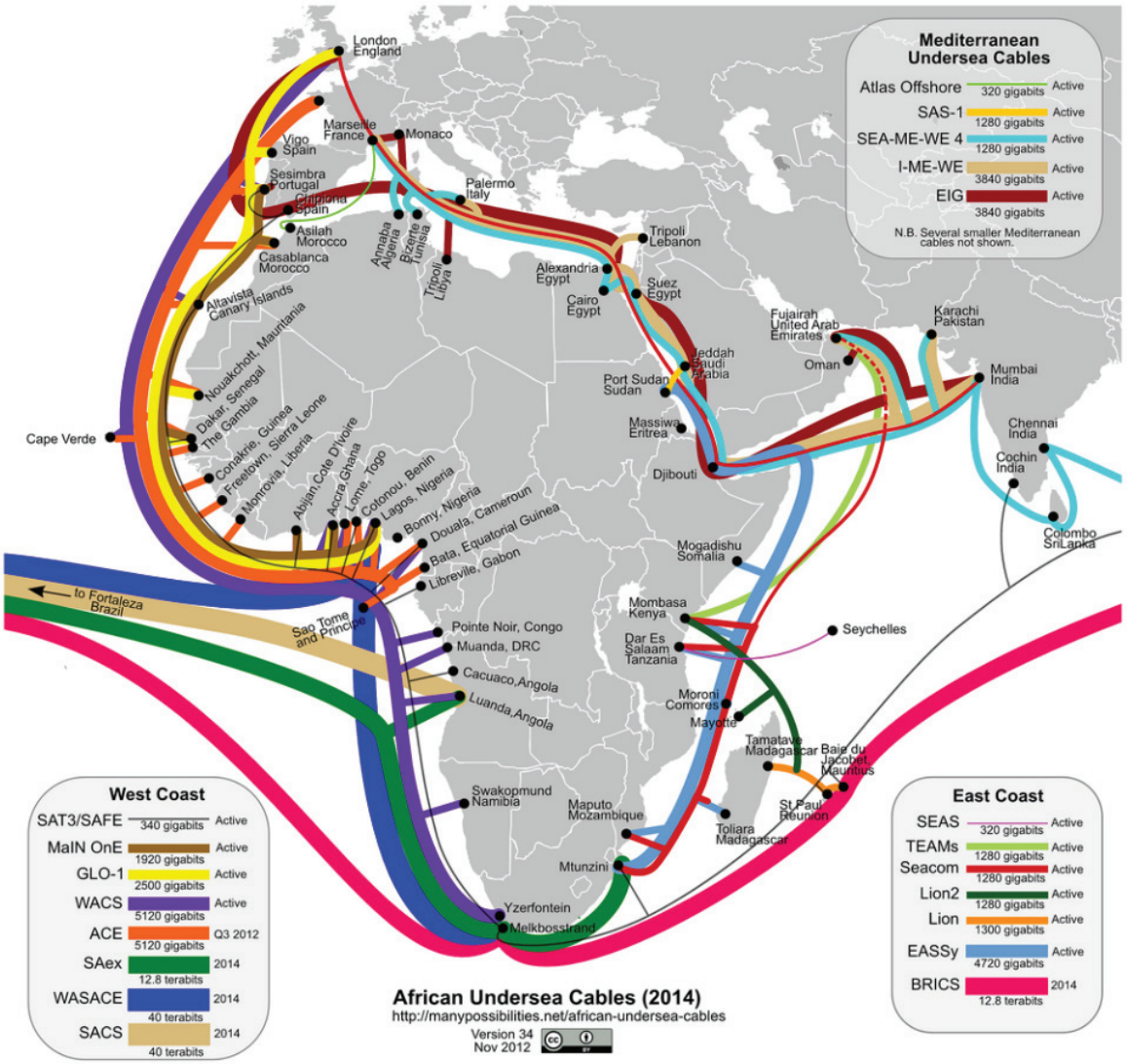


Figure 2.3: African undersea cables by 2014
([AUC, 2013])

In the following section, let us take a closer look at the computer and Internet penetration in some Countries in Sub-Sahara.

2.2 Findings of the Research ICT Africa

Research ICT Africa (RIA) is a network conducting different researches on ICT policy and regulation. It places the research results at the disposal of African researchers, governments, regulators, operators, multilateral institutions, development agencies, etc. for decisions making towards social development and economic growth.

Consequently, we will rely on some RIA findings and statistics to discuss the PC and Internet penetration in ten countries, namely, Cameroon, Ethiopia, Ghana, Kenya, Namibia, Nigeria, Rwanda, South Africa, Tanzania, and Uganda. In these countries,

RIA conducted survey among the population above 15 years old, analysing the access and usage of computer and Internet.

Table 2.1 traces the rate of computer usage in the aforementioned countries in 2011. With the exception of South Africa and Kenya, the results show huge disparities in the geographic computer practice in most of the analysed countries. The population that uses a computer is estimated less than 5% in Uganda, Rwanda, Ethiopia and Tanzania and even 2% or less in Ethiopia and Tanzania.

		Location where the computer is used (multiple response)					
	Users of computer	Work	School, University	Library	At home	Internet Café	At a friends place
South Africa	29,1%	40,2	22,8	6,1	61,1%	29,0%	20,7%
Kenya	21.2%	36,8%	40,2%	16,9%	56,0%	68,8%	45,9%
Cameroon	15,1%	20,7%	33,4%	7,7%	38,0%	63,5%	35,9%
Namibia	13,0%	60,6%	36,7%	28,5%	73,1%	28,4%	45,5%
Ghana	10,0%	42,9%	44,5%	6,2%	72,6%	54,4%	24,9%
Nigeria	7,5%	45,9%	36,1%	4,5%	73,1%	61,8%	58,3%
Uganda	4,8%	45,5%	51,4%	25,0%	35,7%	57,0%	60,9%
Rwanda	3,5%	54,5%	35,3%	18,9%	59,4%	45,2%	25,1%
Ethiopia	2,0%	34,1%	48,4%	9,2%	23,9%	28,5%	5,3%
Tanzania	1,9%	41,0%	23,6%	8,5%	47,7%	65,8%	27,8%

Table 2.1: Individual computer use, 2011
(researchICTafrica.net 2011)

Table 2.2 describes the level of Mobile usage. In all the countries analysed, the level of mobile usage is higher compared to that of computers. Even in Ethiopia and Tanzania, where the computer usage is very low, the mobile usage reached 18,3% and 35,8% respectively. This is due to the fact that mobiles are cheaper and require less ICT skills and electricity than computers. In most of the countries analysed, such as Cameroon, Ghana, Kenya, Namibia, Nigeria, Rwanda, South Africa, and Uganda, people tend to use the mobile phone for social networking rather than for reading and writing emails. We should also note that almost all the mobile owners are using prepaid SIM cards, thereby avoiding to be involved in long lasting contracts with the mobile operators during which fees are charged monthly.

		15+ owning a mobile phone				
	M-phone owners	prepaid	Web-enabled Phones	Social Network	Internet browsing	E-Mail
South Africa	84,2%	87,5%	51,0%	25,4%	27,6%	16,7%
Kenya	74%	99,8%	32,3%	24,5%	25,3%	19,7%
Ghana	59,5%	97,4%	28,5%	11,3%	13,4%	9,5%
Namibia	56,1%	91,8%	30,7%	17,3%	23,8%	12,4%
Nigeria	46,7%	99,0%	22,7%	15,8%	16,0%	14,6%
Uganda	46,7%	98,0%	14,9%	6,7%	7,7%	6,0%
Cameroon	44,5%	99,0%	14,9%	7,7%	8,1%	4,3%
Tanzania	35,8%	99,5%	19,2%	4,7%	5,2%	5,2%
Rwanda	24,4%	90,1%	19,1%	13,6%	14,9%	13,3%
Ethiopia	18,3%	98,4%	6,5%	2,1%	5,1%	9,7%

Table 2.2: Mobile phone access and usage, 2011
(RIA 2011)

Considering the survey and findings of RIA, and the ITU statistics, we draw the following conclusion:

- The computer usage is largely low in Sub-Saharan countries.
- The mobile penetration is increasing very fast.
- The mobile is henceforth the key entry point for Internet usage.
- The use of social networking applications such as Facebook, Wikipedia, etc. is increasing.
- The number of fixed-telephone subscriptions is decreasing in Africa and worldwide.

2.3 Resulting Facts: Communication and Information Devices

From the previous established facts, while emphasising on the penetration of handheld devices such as smartphones, we retain that the information and communication technology could reach new segments of population. In the meantime, people tend to carry mobile devices that are both used as communication and information devices. Communication-oriented mobile features are diversified: users can place calls, send text messages, or connect wirelessly to communicate with other computing devices. As far as the information processing is concerned, mobile facilities should support hand-size-information organisation. This requires more than simple diary, contact management

of spreadsheet applications. Local-adapted applications could offer facilities to process information to professionals, farmers, salespeople, and others belonging to the group of mobile phone users. This may have significant impact on socio-economic activities, particularly in developing countries.

The following comprehensive reasons justify the rapid growth of mobile broadband as means of processing information and communicating compared, for instance, to the use of land line services and computer.

- Land lines require a lot of infrastructural investment like laying cables throughout the country.
- Mobile lines need just fixed relay stations to dispatch the mobile network over large areas.
- Mobiles are easy to afford in terms of cost, unlike land-lines where subscribers are involved in official contracts automatically.
- Mobile devices are portable and do even work where continuous electricity supply is not available.
- On average, the land line subscription takes extremely long. For instance, Cameroonians have to wait 90 days to obtain land line service, some people wait more than one year.

2.4 Mobile Telecommunication in Cameroon

In Cameroon, the mobile telecommunication is no longer a myth. The mobile devices are impacting the socio-economic sector and the cultural as well. Although, the market share is characterised by an increasing number of mobile lines, the lack of service designed towards local needs leads to ambivalent estimates of the existing mobile devices. To regulate the sector, different governmental institutions are defining guidelines, laws, and regulations.

2.4.1 Socio-Economic and cultural Environment

Cameroon covers an area of 475 440 km^2 at the Gulf of Guinea. In 2011 the Cameroonian population was estimated at nearly 20,3 million inhabitants, with 49% men and 51% women. In 2013, the population density is about 46 inhabitants per km^2. The growth rate is close to 2.2%, which explains the population's age structure: 50% are under 17 years old, and 3.4% are over 64 years old (INS 2011).

The Cameroonian rural population is estimated at over 80% of the total population throughout the territory. Considering the period from 2001 to 2010, the global literacy

rate passed from 67,9% to 82,7% respectively. In rural areas, 75,0 % (77,5% of males and 72,6% of females) of people are literate [INS JIF 2012]. Although the gender gap remains, especially in rural areas, the number of literate females is increasing.

In 2012, the Central Intelligence Agency (CIA) records a global economic growth. The annual growth rate was estimated at 4.7%, with a Gross Domestic Product (GDP) of nearly US$ 25.01 billion, and about US$ 2,400 per inhabitant. The current economic sector is characterised by agriculture (overview in Figure 2.4), which grew from 10.36% in 2005 to 20.7% in 2012 of GDP (with 70% of the population involved in agricultural activities); the industry contributed 27.7% of GDP, and the services 51.5% (CIA 2013).

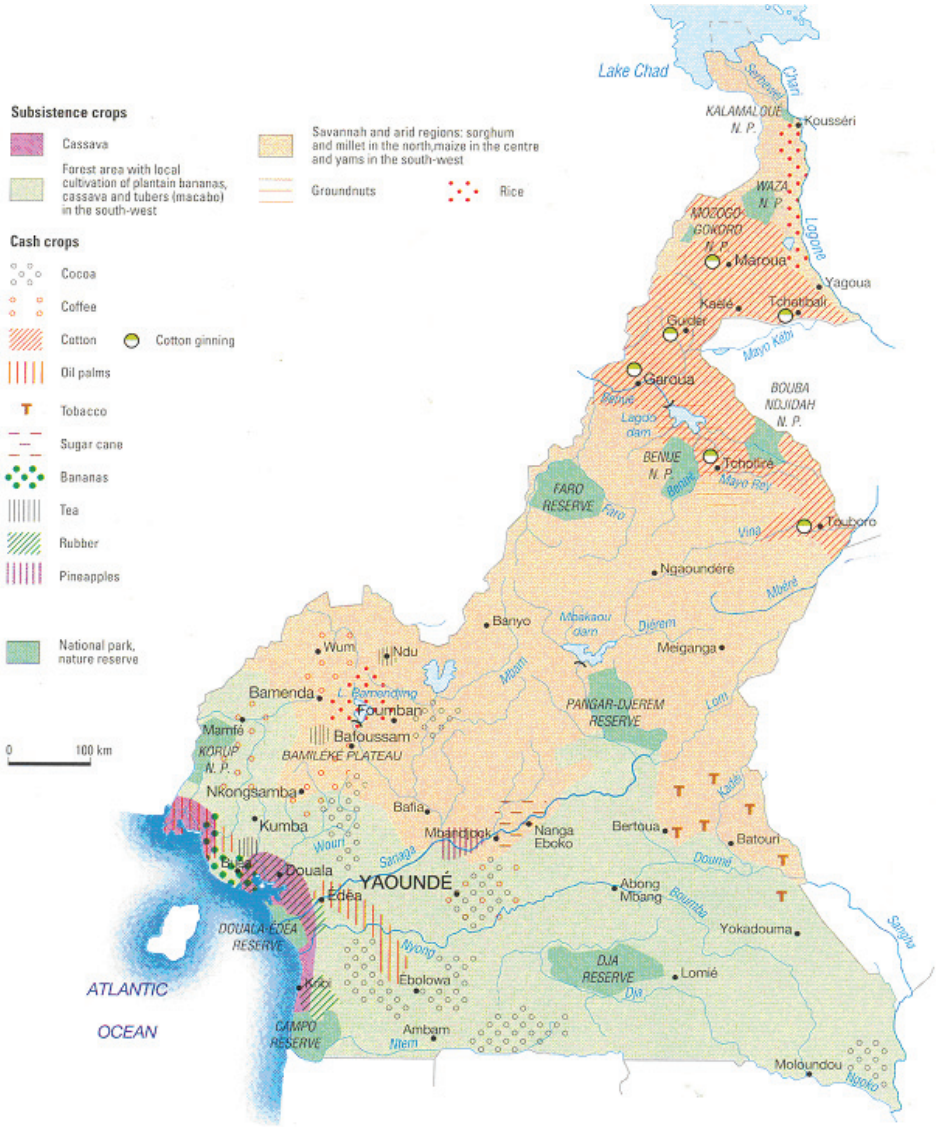


Figure 2.4: Agricultural map of Cameroon
([FAO 2012])

The livestock sector provides income for about 30% of the rural population. From an economic point of view, the rural population plays an outstanding role, for the economic growth through agricultural activities. The following agricultural map highlights the

essential subsistence crops by region.

Expressed through many aspects of social life: manners, morals, lifestyles, beliefs, religious rites, techniques used, family organisation and village communities, fashion, etc., the Cameroonian cultural heritage includes diverse museums (around 1,390), historical sites, cultural landscapes, etc. Culturally, Cameroon is considered as a microcosm of Africa. This is reflected in its linguistic diversity, with nearly 250 language groups recorded. Each language group has its own cultural identity. According to UNESCO, the culture is manifested in three main forms: art, language and technology. More and more people realise that the culture is contributive and favourable to promote and sustain economic growth. In Cameroon, the culture helps to generate revenue, notably through tourism (cultural tourism and ecotourism) and craft, and contributes therefore to sustainable development. ICT may support these cultural manifestations by making them more interesting and visible.

However, some factors are hardly conducive to give rise to sustainable development. The Transparency International's report classifies Cameroon as a country where firms or individuals often pay bribes to get certain services done. In 2005 the Opération Épervier (Operation Sparrow Hawk)[1] was launched by the government to fight against corruption. ICT, through the mobile technology, may support governmental actions aiming to combat such bad practices.

Few studies have been conducted to assess how the penetration of mobile phones is associated to economic growth and improvement of social life in Africa. Gruber and Koutroumpis (2010) have shown a high degree of correlation between the real GDP and the mobile penetration. An analysis conducted by Waverman, Meschi, and Fuss (2005) in some developing countries, has shown that a 10% growth of mobile penetration was associated to 0.6% of economic growth. Thus, effort towards the deployment of services for the local use belongs to the determinant factor. Assuming that mobile phone owners are also users of local adapted services, the penetration of mobile broadband should impact both the socio-economic and cultural environment.

In some African countries the high illiteracy rates limit the efficient use of mobile phones. In Niger, some initiatives have been taken to promote literacy of adults through the use of mobile phones by teaching them where to find numbers, letters, and how to write text message in local languages. In fact, the pervasiveness and impact of mobile phones can favourably contribute, for instance, to:

- support knowledge exchange in diverse sectors, such as agricultural activities;
- create services and optimise industrial processes;
- promote and value cultural means by making them available and visible to tourists;

[1] Opération Épervier is a name given to the government operation for tracking thieves of public funds

- ensure transparency, accountability and traceability in government operations, etc.

2.4.2 Actors in the Mobile Ecosystem

In conjunction with mobile telecommunications, the mobile ecosystem is composed of many participants interacting with each other through diverse services and regulations, building a mobile ecosystem [Anderson 2010].

- **Original Equipment Manufacturers (OEMs**) produce the mobile devices. They determine the operating system to be installed on the manufactured mobile handset.
- **Network Operators** or **carriers** manage the network and offer services to the mobile phone subscribers.
- **Media Owners** and **Content Producers** represent designers and developers who produce mobile content.
- **Aggregators** deal with the distribution of mobile content via online portals or network operators. Users who share and publish items online are aggregation intermediaries.
- **App Stores** refer to market places where native applications are distributed.
- **Consumers** represent the users of mobile devices.
- **Governmental institutions** that provide regulations, policies, and strategies for the development of wireless technology.

2.4.3 Market Share and Structure

In Cameroon, the market of mobile devices is still growing. Since mobile phones made their appearance in the Cameroonian market at the beginning of 2000, a new era of telecommunication began. Owning a mobile phone was a sign of a higher social status.

Nowadays the mobile phone revolution is sweeping through Cameroon like a bushfire. The potential for using mobile phones as a tool for economic development and business has not gone unnoticed in Cameroon. Currently, new job opportunities arise, among which we can enumerate charging service, mobile call boxes, money transfer services, dialling correspondent's number for illiterate people etc. About ten thousand of call boxes and hundreds of cyber cafés contribute to the telecommunication market. The following pictures show two workplaces, call box (CFA F 100 [2] (see Figure 2.5) for a

[2]CFA F (in French: franc de la coopération financière d'Afrique centrale) is the currency used in Cameroon and other central Africa countries

call duration between 0 and 40 seconds, airtime transfer) and phone charging services (see Figure 2.6) respectively.

Figure 2.5: Call box as a workplace

Figure 2.6: Phone charging as a workplace

Nothing seems to stop the triggered booming process of the mobile phone market in the near future. Therefore, the mobile network in Cameroon is the most reliable communication network as in many Sub-Saharan countries. Mobile operators have invested enormously in infrastructural facilities, over 80% of the land area is covered by mobile network [TRB 2012]. According to the Telecommunications Regulatory Board (TRB), the structure for regulating telecommunications in Cameroon, the mobile phone subscribers increased from 103,279 subscribers to 11,6 millions subscribers, between 2000 and 2012 [TRB 2012]. This number does not include non-identified subscribers; in fact, various SIM-cards are sold across the streets without proper registration done by the buyer.

The density of telecommunication means per 1,000 inhabitants is shown in Table 2.3.

Means of telecommunication	**‰ per 1,000 inhabitants**
Fixed telephone	33
Mobile phone	520
Internet users	38
Internet subscribers	0,1

Table 2.3: Density of telecommunication means in Cameroon in 2012 *([Statistiques mondiales 2012])*

Currently, four mobile phone companies share the Cameroonian market of mobile telecommunication. In December 2012, Vietnam's Viettel won the fourth mobile licence in Cameroon. The operating companies offer various services that rather confuse the subscribers. For example, the subscribers are confronted to difficulties while trying

to look through the diversified calling service packages. The plethora of services make the users unsure and even lost.

Table 2.4 shows the market distribution of the only operating mobile companies in Cameroon. Viettel does not operate yet.

Operator	**Subscribers**
CAMTEL	600, 000 (5.17%)
MTN	6, 000, 000 (51.72%)
ORANGE	5, 000 000 (43.10%)
TOTAL	**11, 600, 000**

Table 2.4: Mobile market distribution in Cameroon, September 2012 *([INS 2012])*

Viettel

Currently, the company is planning to be fully operational in 2014. Thus, its services are not yet deployed across the territory. But, the Vietnamese mobile operator promises to cover about 85% of the national territory; to provide second and third generation (2G – 3G) technologies; and to drop the actual cost of phone calls and Internet by 15 to 20% [CRTV 2013].

MTN

With ca. 6 millions subscribers, MTN occupies the first place amongst the mobile operators. Since it is the largest network, it covers hundreds of cities and villages throughout the country. A large variety of services are offered by MTN such as the off-peak tariff called *Y'ello night*, which share calls for CFA F 1/s from 22h00 to 5h:59. The *MTN Save My Contacts* offers subscribers to save the entire SIM book on MTN server and restore it on mobile phone in case of necessity. The *MTN Mobile Money* allows the subscribers to pay their bills or send money to friends and family members or to receive money. *MTN Bip Me* allows subscribers to send messages even without having airtime in their phones.

Orange

Counting ca. 5 millions subscribers, Orange is the second largest mobile company in Cameroon. It is therefore known as a real MTN competitor in regard to the acquisition of subscribers. Orange also offers diversified services, which do not essentially differ from its challenger MTN. Here, we find *Save your contacts* for saving the SIM address book on Orange server. *Call me back* allows subscribers, with an airtime of CFA F 230, to send free of charge a callback message. Subscribers can get access to Internet via their mobiles using the *Mobile Internet*.

CAMTEL

CAMTEL relies on its wide infrastructure to guarantee the availability and efficiency of telecommunication services in Cameroon. Known as City Phone, CTPhone is the CAMTEL branch service responsible of mobile telephony. Concerning the classification of mobile telecommunication, CAMTEL is far behind MTN and Orange. In 2012, ca. 600,000 customers were subscribed to CTPhone. The CTPhone covers selectively only urban areas. Very few rural areas have no access to this service.

CAMTEL has the largest network for inter-urban communication including, the Central African Backbone (CAB). It covers many cities and provides extended connection via the fibre-optic cable to some neighbour countries like Chad and Central African Republic. Since 2005, the fibre-optic cable is laid along the Chad-Cameroon pipeline and connected to the SAT-3 marine cable with access points in Douala, Limbe and Kribi. Consequently, CAMTEL can provide an Internert access of up to two megabits per second (Mbps) to diverse Internet Service Providers (ISPs). In spite of the fact that CAMTEL is holding the largest infrastructure, the network suffers widely from the lack of accompanying services for the users. The following figure highlights the whole CAMTEL network within the country and beyond.

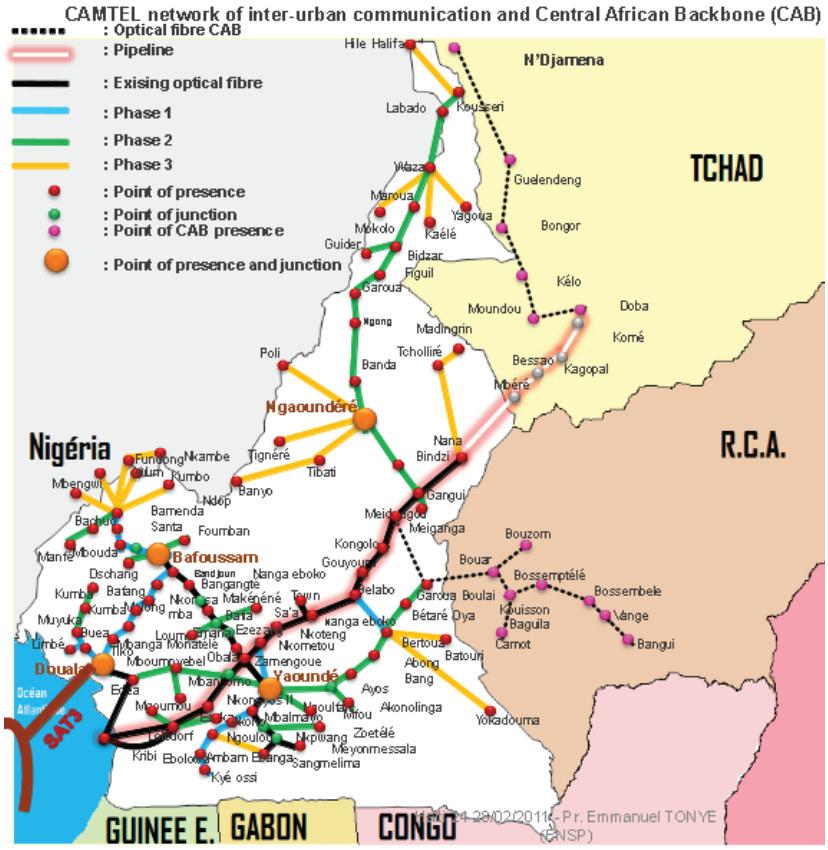


Figure 2.7: CAMTEL inter-urban communication adapted from Tonye *([Tonye 2012], p. 38)*

As many other sub-Saharan countries, Cameroon is looking for ways of innovating mobile practices. Money service MPesa developed in Kenya has its counterpart in Cameroon, called MTN mobile money and Orange money offered by MTN and Orange respectively; and ECOPAY which is not linked to any mobile operator. The mobile customers use these services for sending and receiving domestic remittances. Actually, the prerequisite for holding a bank account in Cameroon is that the account owner provides a proof of monthly or regular income. Thus, it is almost impossible for a farmer, for example, to hold of a bank account. But, mobile money made the way free to everybody owning a mobile phone to be a holder of mobile money account, which permits financial transactions, as it is usually the case when holding a regular bank account.

The detailed services offered by the operating mobile operators in Cameroon are listed in Appendix A.

Currently, there is a lack of Internet Exchange Points (IXP) in Cameroon (8 IXPs in whole Sub-Sahara compared to, for instance, ca. 14 in Germany) [DCM 2013]. A domestic IXP makes the traffic between ISPs most effective in terms of costs, latency and bandwidth. Consequently, all inter-ISP traffic in Cameroon must transit through external IXPs or satellite connectivity, which is more expensive [NAICT07 2007].

To remediate to the high cost of communication (making calls or even sending a text message), users develop new strategies, for instance, the beeping or flashing concept is very popular in Cameroon. The beeping concept consists of an agreed code of communication. Mostly, it is defined and used by young people who innovate the use of this communication approach. To illustrate this concept, let us consider the following scenario.

A student wants to communicate with a classmate; they have no credit in their mobile phone. Both students have previously agreed on a code of communication or language. The following table demonstrates a sample of such a code for setting an appointment.

Beeping time	**Meaning**
One beep	I am leaving my place.
Two successive beeps	I am on the way, but have not yet arrived.
Two beeps with long interval	I cancel the appointment.
Three beeps	I am waiting at the appointment place.
Four beeps	I will be late at the appointment.

Table 2.5: Sample of communication code

Where services and applications are not longer helping, consumers introduce ways to optimise their daily mobile practice, so that they meet an efficient use of the mobile lines. It remains questionable how or whether a model of such arranged practices can be designed using today's technology. As it is now applied, this code of communication has various deficiencies: one beep less or more might lead to misunderstandings, because the beeping time interval is not clear, unexpected situation (new appointment place) is difficult to handle without shifting to oral or writing communication, etc.

2.4.4 Computers as Communication Medium

Related to the electronic communication, the computer-mediated communication (CMC) plays an important role. Regarding the computer utility in Cameroonian, Kolyang stated in his *Habilitationschrift*[3]:

> "*in public administration, less than 10% of the computers are connected to the Internet. 60% of them are not used at all, and those which are, are used simply for text processing and for games. This underlines the need of decision-makers to be trained on the management of technology. In 90% of the cases, a computer is bought where a simple typewriter would have sufficed*" ([Kolyang 2005], p. 3).

In 2012, the computer penetration rate was 20%, while the fixed/fixed-wireless line was estimated at 3%, and the mobile devices over 49%. Also, the global Internet penetration rate is far behind that of the computer; it is around 5%. This is to say, the mobile seems to be the ideal communication device that people could rely on.

2.4.5 Regulatory and Institutional Frameworks

In Cameroon, ICT policy is characterised by some regulations and institutions. The main regulating instruments defined by the government are entitled:

- Law No. 98/14 of 14 July 1998 to govern telecommunications in Cameroon.
- Law No. 2011/012 of 06 may 2011 Framework on consumer protection in Cameroon.
- Law No. 2010/012 of 21 December 2010 Relating to cybersecurity and cybercriminality in Cameroon.
- Law No. 2010/013 of 21 December 2010 Regulating electronic communication in Cameroon.

[3]Habilitationschrift is a German word, which means postdoctoral thesis

Analysing these laws, it should be acknowledged that improvements are necessary in two important aspects. First of all, they could further be enacted to better support the use of indigenous knowledge and practices. Secondly, due the cross-border character of electronic services, the laws should be more harmonised building, at least, a legal framework for the "Communauté économique des États de l'Afrique Centrale" (CEMAC) (Economic Community of Central African States) sub region. Additionally, one may also think about common regulations with the neighbouring country Nigeria, which is not member of CEMAC.

A number of institutions are associated to the control and development of ICTs in Cameroon. In order to regulate the tariff and monitor telecommunication activities of the operators performing across the country, the TRB (2010) proceeds by:

- "*supervising the implementation of legislative and regulatory texts applying to telecommunications;*
- *ensuring that access to the networks open to public is carried out under objective, transparent, and non discriminatory conditions;*
- *guaranteeing healthy and fair competition in the telecommunications sector;*
- *defining principles which are to govern the formulation of rates for services rendered;*
- *investigating requests for authorization and declaration and preparing the decisions there to pertaining;*
- *preparing files for inviting tenders for concessions, in conformity with the legislative stipulations in effect;*
- *defining the conditions and obligations for interconnection and for sharing infrastructure;*
- *providing management for the spectrum of frequencies assigned to the telecommunications sector, notably the assignment and supervision of frequencies in that sector;*
- *establishing and managing the plan for assigning numbers;*
- *submitting to the government any proposal or recommendation tending to develop and modernize the telecommunication sector;*
- *investigating the files for approval of terminal equipment and preparing the decisions there to pertaining;*
- *exercising any other task of general interest that the government might entrust to it in telecommunications sector;*

- *issuing opinions as to legislative bills or proposed regulatory texts in the area of telecommunications;*
- *settling disputes between the operators*".

For instance, TRB censured the high cost of the *interconnection* of mobile telecommunications in June 2012. The interconnection is the process of communicating from one operator to the other. Consequently, TRB claimed the operators to revise the prices downwards to CFA F 28 (0.042 EURO) for calls and 10 for SMS [4].

While TRB ensures that telecommunication is done according to the existing regulations and laws, the "Agence Nationale des Technologies de l'Information et de la Communication" (National Agency for Information and Communication Technologies) (NAICT) encourages and advises the action of the government and public administration, the private sector and the general public on the efficient use of telecommunication within their structure. The management of the top-level domain .cm, which is the country code top-level domain (ccTLD) for Cameroon, is delegated to NAICT.

Concerning the government and public administration, NAICT (2012)

- advises public authorities on the coherent and harmonized development of their technical objectives,
- ensures compliance with international ICT norms and standards,
- fosters environmental protection and good habits while using ICT,
- facilitates the customization of ICT training,
- encourages the implementation of international ICT conventions,
- formulates and ensures the implementation of national ICT development strategies,
- coordinates and supervise the proper execution of inter-ministerial government projects in the area of ICT,
- builds state personnel capacities in the field of ICT.

It supports the private sector in

- promoting ICT applications and utilisations,
- contributing to the development of a secure environment for electronic transactions,

[4]Currently calls cost between CFA F 33 to 37/min for Orange and CFA F 33 to 38/min for MTN; and each SMS costs CFA F 10.5 for Orange and 11.5 for MTN

- facilitating the development and promotion of electronic commerce,
- creating conditions for building consumer confidence.

NAICT supports the general public in

- encouraging Cameroonian people to adopt and utilise ICTs in their daily activities,
- sensitising the public on ICT utilisations,
- facilitating access to ICT and essential public information.

2.4.6 Ambivalent Estimates of Mobile Services vs. Economic Growth

Also in Cameroon, the mobile penetration tends to increase access to health information and financial services, save time and money on transport, and reduce people isolation by improving their overall happiness through keeping in touch with relatives and friends. But, mobile phones are also used for fulfilling malicious acts such as fraudulences or nuisance acts like obscene and harassing calls. Therefore, the milieu of mobile telecommunication is often characterised by ambivalent opinions concerning the use of services provided by mobile phones.

The Cameroonian users of mobile phones benefit from the existing mobile services by improving their way of doing business via saving accounts. Sending money or paying bills using a mobile device is cost-effective. For instance, the fee for transferring an amount of CFA F 10,000 ($\approx$ 15 EURO) is CFA F 100 ($\approx$ 0,15 EURO); with local banks, this transaction will cost CFA F 500 ($\approx$ 0,76 EURO), and also traditional transfer agents will charge more. Considering the mobile impact, in 2012 about 1.7 billion people worldwide have mobile phones but no bank accounts; this is the statement of the Consultative Group to Assist the Poor, which is an independent policy and research centre housed at the World Bank.

Furthermore, phone subscribers may use their mobile devices for accomplishing diverse tasks, such as paying bills. As an example, to avoid the ever long waiting queue at AES SONEL - the Cameroon electric power company - subscribers use their mobile to pay their electricity bills. But often, there are transaction failures due to network issues. This affects the user's satisfaction negatively because they may lose money and the reimbursement procedure is an arduous task.

Besides the reticence of some subscribers to try new products, many other uncomfortable situations lead to user dissatisfaction. In Cameroon, electricity blackouts are common. Sometimes, blackouts can last a whole day, this may affect the activities supported by means of cell phones. For example, mobile phones may get down due to emptied battery.

Moreover, some subscribers get discouraged by the slowness of administrative service either due to the high user demand, or laxness of the working personal. Other subscribers do not see any use of a mobile phone other than a device for making or receiving calls and text messages.

2.5 ICTs in Rural and Suburb Communities

To improve the digital training and the Internet penetration rate, the Cameroonian government has started the implementation of a Multipurpose Community Telecentre (MCT) programme across the country since 2003. With a particular emphasis on rural areas, the ultimate objective of this project is to create 2,000 MCTs by 2015. Figure 2.8 presents the services to be provided by each MCT. The two major objectives are:

- being accessible to the whole community, without discrimination;
- providing access to telecommunications services, computer, audiovisual and Internet at a lower cost.

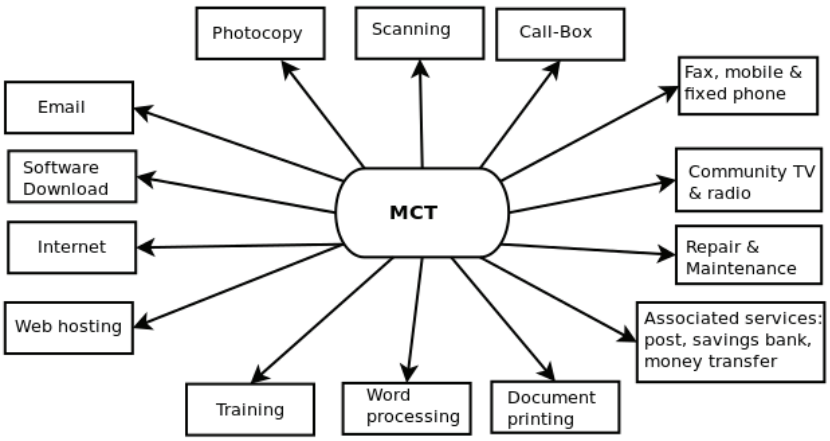


Figure 2.8: MCT services
([Minpostel 2011])

But the programme is undergoing diverse challenges. The difficulties of such an endeavour consist, amongst other things, in the fact that there is a lack of trained ICT teachers, clearly defined objectives for digital training, basic requirements such as electricity, roads accessible by vehicle.

These challenges have multiple implications: since 10 years, only 115 MCTs have been created and another 90 are planned for the end of 2013. By this time, the existing telecentres undergo hardship: abandonment of projects by contractors for various reasons,

poor workmanship, weak security system causing MCT burglaries, etc. [CIN 2003].

Furthermore, the usage of the centre is also determined by the ability of maintaining the installed infrastructure. Presently five engineers from the Ministry of Posts and Telecommunications (MINPOSTEL) are responsible of the maintenance tasks for the whole country. MINPOSTEL, in collaboration with CAMTEL and National Advanced School of Public Works (NASPW), has just promised to ensure the maintenance of the centres.

In fact, the effective and sustainable realisation of such a programme requires the involvement of the local population in the prior stage of its implementation. The indigenous population plays an undeniable role, they appear as those who shall support the MCT and ensure its sustainability through regular visits. In order to do so, the local population may rely on a participative approach based on mobile technology that aims, on the one hand, to efficiently use the offered services, and, on the other hand, to provide local content to the centres, thereby building an indigenous knowledge base. Thereby, sufficient consultation and coordination amongst stakeholders involved in these telecentres are recommended for contributing to the programme success.

Although the global illiteracy rate is regressing, it remains as social and educational barriers for many people who live in underserved, remote or rural areas; the MCTs may contribute to improve the literacy rate of those areas.

2.6 Constraints as Bottlenecks of Mobile Telecommunications Penetration

Besides the basic services (phone calls and SMS), the mobile operators mostly offer services or applications that are SIM-dependent and therefore limited. Using those services or apps, the subscribers are immediately committed to official and costly contracts with the mobile companies. In regard to the services, the restrictions, notably in form of contract, may be understood as security measures taken by the mobile operators. For example, mobile operators must ensure the liability of mobile money services.

Concerning the development of mobile applications, the Cameroonian apps market is poor, as many other Sub-Saharan African markets. Consequently, the existing infrastructure is used below its capacity and operate in an under-employed state.

Hence, we distinguish various challenges that influence the adequate expansion of mobile technology in Cameroon. The challenging factors may easily turn into constraints

and weaknesses of existing mobile technology. Therefore, it is important not only to be aware of them but know how they may impact possible mobile services to be introduced.

2.6.1 Technical Constraints

SIM-dependent apps and services limit the spread of telecommunication services, and the absence of tailored apps and appropriate hardware impede the networking of various stakeholders.

Limited and costly bandwidth leads to a poor quality of service and hinders its effective exploitation. For instance, CAMTEL offers an unlimited mobile Internet connection for CFA F 23,850 (36.4 EURO)/month, for a download speed of up to 0.36 Mbps, while the German mobile operator T-Online offers its mobile connection for 9.95 EURO (CFA F 6,530)/month, for a download speed of up to 21.6 Mbps. Additionally, the lack of national domestic IXP induces expensive connectivity costs.

The characteristics of mobiles themselves are also challenging factors: limitation of memory, processing and energy power, screen size, etc. Those factors are regarded as constraining because they influence the deployment of mobile applications.

2.6.2 Infrastructural Constraints

Obviously, electricity is vital for the full operation of telecommunication infrastructure. Long lasting electricity blackouts, which may be classified as an extended factor, hinder the infrastructure to be fully functional.

In Cameroon (as in many other countries in Sub-Saharan African region), terrestrial Internet connection is generally not available or reliable. Part of the problem is that, at least as far as developing countries are concerned, costs for terrestrial Internet connection are high in the short-term. Therefore, hired satellite connections are used (for instance, VSAT in Cameroon). Ultimately, the use of such satellite connections leads to high cost in the long term.

2.6.3 Social Constraints

There is a lack of financial resources, particularly in the rural areas where the majority of the population is involved in informal and not continuously remunerated activities. This impedes the prompt investment in new technologies or services.

2.6.4 Cultural Constraints

The cultural diversity of Cameroon influences the deployment of ICT solutions. Since indigenous and cultural knowledge is often tacit and oral, it is another challenge to record and document it, so that it can be used for the adoption of telecommunication services locally.

2.6.5 Skill Constraints

In Cameroon, there is a lack of trained staff and suitable training environments that could help the local population to get acquaintance with the new technological means of telecommunication. Consequently, the introduction of Computer Science in secondary education (ministerial Decision N° 3475/D/63/MINEDUC/CAB, 17 June 2003) was characterised by the insufficiency of trained teachers, in addition to obsolete equipments.

3 Mobile Commerce in Perspective

This chapter describes electronic commerce done by means of wireless devices. The first section specifies what the mobile commerce is intended to be. Next, different types of mobile applications are briefly presented. What follows are the different forms of mobile commerce and how they influence the way of doing business.

The following section examines a few of applications that aim to support the new way of conducting business via wireless devices, including the Cameroonian experience. Related advantages and critical issues (security, fraudulent practices, etc.) are pointed out in order to raise awareness of the different stakeholders involved either using or developing applications for electronic commerce.

The chapter ends with the details of the required infrastructure for running a m-commerce solution.

3.1 Defining Mobile Commerce

Mobile electronic commerce (or m-commerce) is the way of running business activities (distributing, buying, selling, marketing, and advertising products or services) electronically via mobile devices, such as cell phones and smartphones. M-commerce differs from e-commerce in the media used; e-commerce relies on computer networks to conduct the business activities.

According to Stair and Reynolds ([2012], p. 324):

> "*During the last decade, it is estimated that the Internet created 1.2 million jobs, including half a million jobs on e-commerce companies and companies that deliver the physical goods, and another 200,000 jobs at Internet service providers.*".

Due to the pervasive characteristic of mobiles, we expect growing business activities in the field of m-commerce in general.

3.2 Trends and Type of Mobile Applications

What is a mobile application or an app?

In fact, the term app is described by Mugoya ([2011], p. 8) as:

> "*a lightweight application or piece of software that can be deployed remotely over the Web or offered remotely as a service (software as a service). Apps include the familiar mobile apps found on app stores; Web applications and Web platforms; and easily deployable, lightweight desktop apps (like those on the Apple Store). [...] Traditional software often requires complex installation and maintenance processes [...]. Apps on the other hand are built to be lightweight and*

simple enough to install quickly and with almost no technical knowledge. This is the main difference between apps and traditional software".

In relation to mobiles, an app is a complete piece of software deployed on mobile devices and aimed to fulfil a specific task. Compared to traditional software, an app tends to be easy to build, to market, and its price is relatively low.

Presently, the number of apps is rapidly growing in the different stores (Google Play with over 1 million apps; Apple App Store with 900, 000; and Windows Phone Store with 175,000 apps). The trend is also due to the technological factor, the fifth revision of the HyperText Markup Language (HTML5) standard and the Cascading Style Sheets level 3 (CSS3) are enormously contributing to the growth of new generation of mobile Web and hybrid apps.

The existing approaches of Web standards offer an interesting combination of native and Web apps by ensuring the cross-platform compatibility and accessing the phone devices (camera, GPS, user's contacts, etc.).

These trends are justified by the following advantages:

- write the application code once and let it work on multiple devices,
- make the application useful, even though the connectivity to the Web is limited or unreliable,
- write the application fast,
- market the application at low price.

The market demand is nowadays moving towards mobile Web solutions. Fling (2009) thus defines the mobile Web as the only platform that is available and works across all mobile devices. To predict the growth of the mobile Web compared to the desktop Web from 2009 to 2015, Figure 3.1 gives an overall insight.

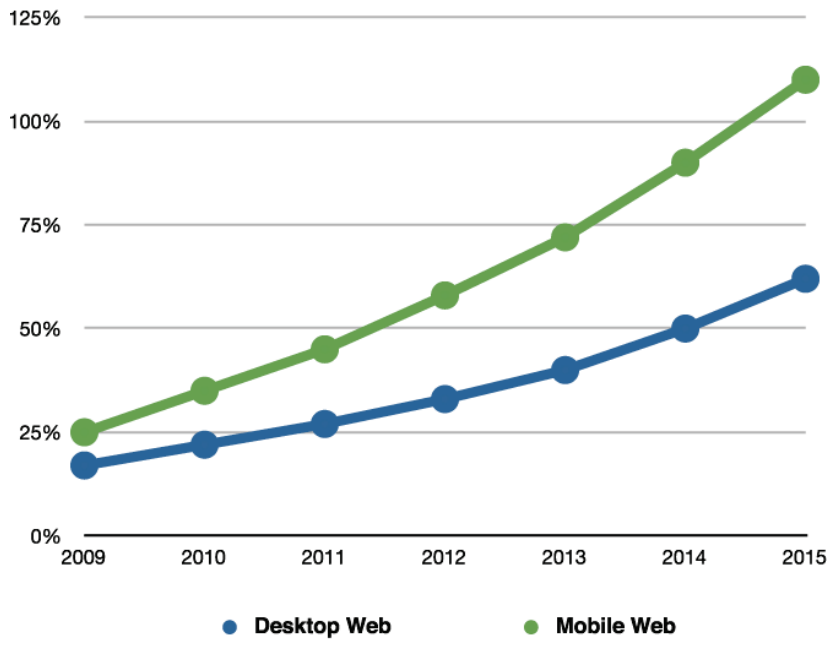


Figure 3.1: Predicted growth of mobile Web access
([Fling 2009], p. 33)

There is a range of generic mobile apps like Facebook Mobile, Google Mobile, Wikipedia Mobile, and so forth, which are mobile Websites designed to match every web-enabled phone. Also, various companies are providing mobile counterparts of their desktop Websites.

Nevertheless, the rapid trend of Web standards coincides with other challenges linked to the diversity of existing browsers and in particular their incongruent development. Choudhary ([2012], p. 1) articulated that:

> "*Rapid evolution of web technologies has lead to inconsistencies in web browser implementations, which has resulted in cross-browser incompatibilities [...] – situations in which the behavior of the same web application varies across browsers*".

There are three different approaches to develop mobile applications. The first approach is based on dedicated programming languages that generate executable binaries from the program code, building the so-called native apps. The second approach relies on Web technology, resulting thereby to applications known as Web apps. The last approach is the association of the first two, i.e, native and Web: we obtain hybrid apps.

3.2.1 Native Apps

Concerning native apps, they are designed to run in a specific Operating System (OS) environment. Native apps are coded with a specific programming language, for ex-

ample ObjectiveC for iOS or Java for Android platform. They are fast, reliable, and powerful but are tied to a specific mobile platform. Migrating a native app to another mobile platform means to duplicate it using the appropriate programming language.

Native apps are characterised by:

- offering best user experience, rich design,
- being executed directly by the OS and using explicitly the OS APIs,
- having access to mobile devices like speaker, accelerometer, camera, GPS etc.,
- being fast, reliable and powerful,
- being downloadable from a popular app store and market place of the device,
- having high cost for developing, testing, maintaining and supporting multiple platforms,
- being tied to specific mobile platform and not easy to port to other mobile platforms.

Depending on the mobile OS, developing a native app affords different expertise and leads to different source code. Below we summarise the characteristics of the five most used mobile operating systems (Android, iOS, Windows Phone, BlackBerry, and Bada).

	 Android	 iOS	 Windows Phone	 BlackBerry OS	 Bada
Languages	Java, C/C++	Obj-C, C/C++	C#, VB.NET	Java, C/C++	C/C++, Java
Tools	Android SDK [1]	Xcode	Visual Studio, Windows Phone Dev Tools	BB Java Eclipse Plugin	Bada SDK
Executable Files	.apk	.app	.xap	.cod	.*
Application Stores	Google Play	Apple iTunes	Windows Phone Market	BlackBerry App World	Samsung Apps

Table 3.1: Summary of native app development
* Samsung Bada applications rely on many file extensions: .xml, .htb, .exe, .sys and .dat which are stored in a RAR or ZIP archive.

3.2.2 Web Apps

In fact, the only thing all the previous listed operating systems have in common is that they all provide a mobile browser that can be accessed via a programme, also from the native code. Obviously, the mobile browser is the basic tool for running Web applications. A definition is given by Oehlman and Blanc [(2011, p. xiii)].

> "*A mobile Web app is an application that is built with the core client Web technologies of HTML [HTML5], CSS [CSS3], and JavaScript, and is specifically designed for mobile devices*".

The characteristics of Web apps can be summarised as follows. Web apps:

- are written using Web technologies.
- are easy to create, maintain, and publish.
- are executed by the browser, not by the OS.
- are slow during loading due to network latency.
- are simple to deploy across multiple platforms.
- have no access to certain mobile features such as camera, speakers, file system etc.
- may not be installed.

3.2.3 Hybrid Apps

Hybrid apps provide a good compromise between native and Web apps. They are platform-independent Web apps, packed as native apps. They are created by combining the good things from the native approach with those from the Web. For example, we can easily create a version of an iOS app for Android using this approach and the cost will be less than a native version.

Another approach for developing platform-independent apps is the development of cross compilers, which compile the application code for a target platform. For example, code written in JavaScript is compiled in a native code of a specific platform by means of certain frameworks such as Appcelerator Titanium or MonoTouch.

The development of hybrid apps is supported and facilitated by means of development frameworks like Sencha, PhoneGap, etc., which provide libraries for accessing the hardware features of mobile devices. The hybrid apps are characterised by:

- embedding Web technologies in native apps which have selected portions written using HTML5,
- having access to mobile devices using specific JavaScript libraries,
- running on different platforms without rewriting the entire code new,
- being able to publish into app markets.

Sometimes hybrid apps suffer from low performance and responsiveness because they need to move between the web and native components to perform tasks. If hybrid apps have to get some content via the Web, they can also be confronted with bandwidth constraints.

3.2.4 Other Mobile Applications

There exist two other types of applications: The mobile Web Widgets and the SIM dependent apps.
Mobile Web Widgets, which consist of stand-alone chunk of HTML code, are executed by the users in a widget platform like Opera Widgets, Nokia Web RunTime, Yahoo! Blueprint, or Adobe Flash Lite.

SIM apps are applications or services offered by a specific mobile network operator. These services are embedded into the SIM card and therefore they depend on the mobile operator. They are not available on the app market.

3.3 Mobile Commerce in Sub-Saharan African Region

The boom of mobile technology in Africa has opened up various opportunities to people to use new methods of supporting business transactions by employing mobile devices. In Africa, the limited availability and high cost of fixed-line Internet access pushes many users to use the Internet via their mobile devices. Actually, the fact that non-banked people trust in phones to be their banks means that they are accepting the same phone as a mode of payment for goods and services.

A study related to the global consumer perspective on mobile shopping conducted by the largest independent mobile network - called InMobi [2011] - reveals that mobile Internet users in Africa prefer to shop from their mobiles (46%) than from their desktop computers (10%) or in-store (44%).

Regarding the economic impact of mobiles in Africa, the authors Aker and Mbiti ([2010], p. 214) stated:

> "*The rollout of mobile phones in sub-Saharan Africa over the past decade has introduced a new search technology that offers several advantages. First, mobile phones greatly reduce search costs. While mobile phones require an initial fixed cost, the variable costs associated with their use are significantly lower than equivalent travel and other opportunity costs. In Niger, for example, an average trip to a market located 65 kilometers away can take 2–4 hours roundtrip, as compared to a two-minute call. Using a local daily wage of 500 CFA francs (US$1) per agricultural laborer in Niger, mobile phones reduce search costs by 50 percent as compared with personal travel. Mobile phones can also allow people to obtain information immediately and on a regular basis, rather than waiting for weekly radio broadcasts, newspapers, or letters. Furthermore, rather than being passive recipients of information, mobile phones allow individuals and firms to take an active role in the search process, enabling them to ask questions and corroborate information with multiple sources*".

But, the African app market is still poor. Beyond services, we assume that mobile applications are a key feature of mobile device usefulness on the one hand and, for an efficient use of mobile infrastructure on the other hand. We explored some pioneer of mobile services and applications that will help us to explore and understand the as-is state of mobile services and apps in Sub-Sahara in general. There is a comprehensive list of African apps in appendix B.

In Camerooon, the Economic Commission for Africa (ECA) states that the Cameroon National Information and Communication Infrastructure (NICI) declares the electronic commerce as the priority of the government policy since 2006 [Mensah/Bahta/Mhlanga, 2006]. In fact, the market of m-commerce in Cameroon is still in its embryonic phase. In general, no appealing m-commerce Web sites that display information in a format convenient to mobile device exist; no local apps for supporting m-commerce activities exist.

3.4 Types of M-Commerce

M-commerce services include any business transaction executed electronically between companies (business-to-business, or B2B), companies and consumers (business-to-consumer, or B2C), consumers and other consumers (consumer-to-consumer, or C2C), public sector and business (government-to-business, or G2B), and the public sector to citizens (government-to-citizen, or G2Ci).

In the following sections, we take a look at applications and general issues that support m-commerce in general and analyse how far these applications are operating or may run in Cameroon.

3.5 Financial Web Sites and Applications

Mobile financial applications are likely the driving force for the development of m-commerce. They include a wide variety of applications, comprising Web sites for product marketing, banking apps, money transfers, mobile manufacturing systems, etc.

3.5.1 Web Sites

Nowadays, various retailers and wholesalers as well build special mobile Web sites for users of mobile devices. In order to attract mobile users to the Web sites, the Internet Corporation for Assigned Names and Numbers (ICANN) created a .mobi Top Level Domain (mTLD). The .mobi domain is used by mobile devices to access Internet resources. In addition, mTLD provides technologies and tools that help all parties involved in mobile web development to increase the quality of their products.

Powerful Web sites are Web applications that permit users of mobile devices to purchase goods by placing an order: adding product in a cart, paying, tracking the shipment process, etc. eBay and Amazon.com are two worldwide examples. Although they can be accessed by various mobile devices, eBay and Amazon.com provide full mobile versions of their applications that shall meet customers' needs.

In Cameroon, besides the low Internet connection, the lack of physical house addresses hinder the full deployment and use of such web applications. Considering the Cameroonian context, where in general, Web sites for electronic business are rare, the platform sasayez.com provides a contextual concept focusing on the Cameroonian diaspora as target group. Sasayez.com is an online shop that gives the Cameroonian, particularly those living abroad, a platform for sharing and offering according to African culture. The concept of sasayez.com consists in the following steps [SASAYEZ.COM 2013]:

- Choosing products and adding them to cart.
- Paying online.
- Receiving a unique transaction code.
- Calling relatives or beneficiary in Cameroon, done by sasayez.com itself.
- Relatives or beneficiary collect the package at the delivery points, which are commonly supermarkets.

In fact, sasayez.com is exclusively operating in three main cities in Cameroon, i.e, Douala, Yaoundé, and Bafoussam. Although the sasayez.com idea is very much appreciated by the diaspora, there is a lack of intermediate coordination structures between sasayez.com and the delivery points in Cameroon, structures that can deal with orders and shipments in situ.

Furthermore, there are few elementary Cameroonian Web sites for product advertising. If such Web sites exist, they are mostly out of date.

3.5.2 Banking

Mobile banking is a term that describes the activity of performing account transactions, balance checks, credit applications, payments and other banking transactions through a mobile device such as a mobile phone.

Offering business services, mobile phone applications can boost business growth across different areas worldwide assuming that there is a operating network such as Internet. Here are two significant mobile banking apps: the well known MPesa and the recently developed ECOPAY.

The Kenyan Experience: MPesa

MPesa, a word composed of "M" for mobile and "Pesa" for "money" in Swahili language. It is an app for money transfer application and service available in Kenya [Safaricom 2012].

Motivation: Trigger of this app is to create a service which allows microfinance borrowers to conveniently receive and repay loans using the Safaricom mobile network.
Features: This app for mobile money encompasses services such as:

- Deposit and withdraw money.
- Check drugs availability.
- Pay bills.
- Purchase airtime.
- Transfer money to both users and non-users of M-Pesa.

Effect: This banking service used by non-banked people, started in Kenya and is now available in many other countries such as Tanzania, Afghanistan, South Africa, etc. In March 2012, M-Pesa counted over 14,6 million subscribers in Kenya and had in charge a network of over 28,000 agents across the country [Safaricom 2012].

Technical requirement: MPesa is SIM dependent, i.e., it depends on the mobile operator; in this case on the Safaricom.

The Cameroonian Experience: ECOPAY

Similarly to the Kenyan experience, the prototype of a m-payement platform called ECOPAY, has been developed since 2012. The ECOPAY platform aims to bring finan-

cial services to consumers via mobile money services and ECOPAY Network Partners such as banks, microfinance institutions and agents [Nana 2012].

Features: ECOPAY app is used to:

- pay bills,
- make shopping on websites,
- withdraw money from an Automated teller machines (ATM).

Effect: Used by few Cameroonians as an experimental platform, ECOPAY is not yet widely launched across the Cameroonian territory.

Technical requirement: ECOPAY is SIM independent, i.e, it is designed for smartphones and Java ME enabled mobile phones.

3.5.3 Marketing and Advertising

While customers are making their purchase decisions over the Web, product advertisers may gather information about their behaviour and preferences. Obviously the analysis of this data is a difficult task because some visitors do not always provide personal data such as name, address, e-mail address or phone number. Nevertheless, a good analysis of the gathered data helps the Internet product advertiser to identify the portion of their market and to react aim-oriented and therefore provide tailored mobile advertisings, shortened as *ads*. Mostly used for B2C, the process of identifying a specific group of customers is called market segmentation, because it divides the customers into subgroups classified according to the characteristics such age, gender, marital status, geographic location etc. Mobile ads are commonly used by publishers such as mobile Web sites, application developers, mobile operators. The publishers generate benefits on the basis of [monetizepros 2003]:

- Cost Per Thousand (CPM): the advertiser pays the publisher for every 1,000 ad impressions or site impressions, meaning site request.
- Cost Per Click (CPC): the advertiser pays the publisher for each ad click or each site impression.
- Cost Per Action (CPA): the advertiser pays only for clicks that subsequently lead the visitor to complete an action, for instance, purchasing a product, downloading a document, signing-up a newsletter / membership, etc.

In fact, a marketing process is commonly summarised in four words: product, price, place and promotion (usually called 4 P's), described as follows:

1. The right **product**
2. sold at the affordable **price** for customers,
3. in the right **place** accessible to customers
4. using the most suitable **promotion** for communicating with customers.

Indeed, known as the premier global non-profit trade association, the Mobile Marketing Association (MMA) aims to promote, educate, measure, guide and protect the mobile marketing industry worldwide by providing guidelines and standards for m-marketing. Actually, it represents all actors playing a role in the m-marketing value chain. Presently, it counts more than 700 subscribed members. The majority of the members are companies. The MMA's global headquarters are located in the United States. There exist different regional branches including North America (NA), Europe, Middle East and Africa (EMEA), Latin America (LATAM), and Asia Pacific (APAC).

MMA has provided a Code of Conduct aiming to prevent the misuse of m-marketing. The Code of Conduct comprises five categories [MMA 2008]:

1. Notice
2. Choice & Consent
3. Customization & Constraint
4. Security
5. Enforcement & Accountability

According to MMA, the global intention of this code is not to replace existing regulations defined by local or governmental laws but rather to regulate a wireless carrier's ongoing proprietary communication.

Additionally, MMA provides some guidelines in a document called **Mobile Advertising Guidelines**, which encompasses technical specifications, global formats, guidelines and best practices. The guidelines intend to reduce the effort required to produce creative material, to ensure that advertisements display effectively on the majority of mobile phones and, finally to ensure that advertisements provide an engaging, non-intrusive consumer experience.

Moreover, MMA stipulates that Mobile Advertising Guidelines

> "*are designed to establish a common and basic set of standards adopted by all [...] parties [handset manufacturers, operators, content providers, agencies, brands*

> *and technology enablers] and by doing so both accelerate market development and ensure consumer acceptance.*" ([MMA 2011], p. 2)

In Cameroon, traditional channels (radio, television, and poster) are predominantly privileged compared to modern and ubiquitous channels like mobile devices. So, there is need to explore the marketing approach done by means of new technologies.

3.5.4 Manufacturing

Manufactures and suppliers can rely on mobile application to execute their supply chain operations by means of mobile network and therefore raise their business profitability. For this purpose, appropriate apps are necessary to support the supply chain operations. In Cameroon, there is no application with appropriate features that may support the electronic communication between manufactures and suppliers, except the SMS service or phone calls.

3.6 Advantages of Mobile Commerce

Organisations or individuals that rely on m-commerce to conduct their business can take some advantages of it. Below we describe an non-exhaustive list of some advantages.

3.6.1 Reducing Costs

Consumers and merchants benefit from the virtual commerce by reducing or eliminating various costs and time-consuming steps that occur throughout the order and the delivery process. Consumers order products from their home, office or on the way without visiting the store. The payment of services or goods is done from the mobile device. Companies can reduce the need of inventory at all the intermediate delivery points.

3.6.2 Speeding the Flow of Goods and Information

After some time, a trustful electronic communication channel may be established between buyer and seller. The channel creates a relationship that improves the goods and information flow between the two parties.

3.6.3 Increasing Accuracy

M-commerce features allow the buyers to enter themselves the specifications of the product they want to purchase and the order information such as delivery address, phone number etc. The more the seller can specify the product needed, the more is the information accuracy, and possible human data-errors that would have been done by the seller are reduced.

3.6.4 Improving Customer Service

In general, m-commerce services allow customers to follow the order process by tracking the order status. Consequently, they can easily plan the delivery date. This increases the customer satisfaction and improve the service. The delivery process may be considered as an evolving area of investment for suppliers relying on wireless network.

3.7 General Issues of M-Commerce

Despite the growing number of m-commerce applications, conducting m-commerce comes with numerous obstacles or challenging issues, which need to be tackled. Some challenges may hinder considerably the effective and efficient operation of m-commerce systems. Here we address some of them. In general, those issues need to be addressed prior to the deployment of mobile applications on a large scale.

3.7.1 Security

The payment procedure that uses credit cards to purchase items is automatically linked to the Payment Card Industry (PCI). Therefore, the PCI security standard is adopted by organisations involved in m-commerce payment by safeguarding credit cards data (card issuer, cardholder, the merchant, etc.). Diverse efforts are done to reduce fraudulent credit card use. For example, Visa has developed an instantaneous rating technology that submits potential fraudulent transaction to the financial institution that issued the card. Doing this, Visa expects to reduce the charges due to fraudulent credit card by 40% [Stair and Reynolds 2012].

3.7.2 Theft of Intellectual Property

With the help of computers and the Internet, it is easy to copy and distribute digital content. However, intellectual property does not include only works of the mind like books, films, music, but also processes, and software.

3.7.3 Fraudulent Practices

Attackers use diverse techniques aiming to infiltrate the users' mobile devices. In fact, these techniques include ways of misleading users into downloading malwares or spywares unknowingly. There are three important approaches the attackers rely on.

Social engineering threat
The attackers use it to entice mobile users to performing actions that share confidential information in a misleading way. Three techniques belong to social engineering: *repackaging* the app once downloaded, *update attacks* (updated or upgraded apps containing malicious code) [Zhou and Jiang, 2012], and *drive by download* (automatically launched downloads via malvertising).

Threat known as physical
This happens when the attacker accesses the device physically; infiltration while the phone is connected to a computer, the phone is shared by third parties, stolen and found again after malicious codes have been injected in.

Sniffing network connections
Vulnerable connections (Wi-Fi or Bluetooth) can be used by attackers to infiltrate mobile devices or data sent over the network can be intercepted and compromised if the message is not encrypted.

Moreover, m-commerce users can become victim of phishing emails, online auction fraud and click fraud. These are frauds that occur over the Internet. Commonly, *phishing emails* are sent inviting the receiver to visit fake Web sites, appearing as legitimate, where a script collects personal information.

In a pay-per-click online advertising, a *click fraud* may generate additional clicks beyond the legal click number using an automated script. In the majority of cases, buyers purchasing person-to-person auctions can be victim of online auction fraud. For example, a fraudulent practice was detected in April 2009: An individual sold on eBay between 2001 and 2007 counterfeit software for a retail value of more than $1 million [pcworld.com 2009].

3.7.4 Online Profiling

In order to produce targeted advertising, many Web advertisers rely on the process of *clickstream data*, which corresponds to the data collected on the Web sites that online users have visited and the items they have clicked. In doing so, visitor's data are

collected systematically. This practice is called *online profiling*; it leads to the invasion of customer privacy.

3.7.5 Collecting Sales Taxes

We could also mention the challenge deriving from collecting sale taxes. Because the Internet has no boundary, people involved in sales over the Internet by means of electronic devices try to avoid taxes. To collect taxes from online sales is not an easy task for the affected government. Notably, if it comes to person-to-person sales, involving two or more countries.

3.7.6 Legal Jurisdiction in Cameroon

To provide a certain framework for legal regulations concerning threats in electronic communication, the Cameroonian government relies on diverse laws and institutions.

According to Law No. 2000/011 (19 December 2000) related to copyright and neighbouring rights, works, which include computer programs or software, are protected in the Section 3.-(1), declaring:

> " *3.-(1) This law shall protect all literary or artistic works, irrespective of the mode, worth, genre or purpose of the expression, notably:*
>
> *(a) literary works, including computer programs;*
> *...*"

Law No. 2010/012 (21 December 2010), which deals with issues related to cyber security and cyber criminality in Cameroon, mandated the NAICT to secure the Cameroonian cyberspace with the following roles [IST-Africa 2013]:

> "
>
> - *Annual audit of Information systems of Institutions (public and private), which include: Telecommunication operators, Internet Service Providers (ISPs), financial institutions (Banks, micro-finances, Insurance companies, Money transfer companies and Electronic Commerce companies);*
> - *Under the National Public Key Infrastructure (PKI), ANTIC is the Root Certification Authority (CA) and the Government CA. This is the only PKI system legally recognised in Cameroon.*
>
> "

3.8 Required Infrastructure

To run a m-commerce solution successfully, we need the following infrastructural components.

1. **Web Server Hardware**
   A web server hardware is a first basic element of the infrastructure. The capacity of the hardware depends on the transactions to be processed and the software to be installed.

2. **Server Operating System**
   The Operating system is the second basic element after the hardware. In addition to it, a Web server software is needed.

3. **Web Server Software**
   There are various types of Web servers that are able to host Web sites. The two most used Web server software are Apache HTTP Server and Microsoft Internet Information Services.

4. **M-Commerce Software**
   The m-commerce software is the application that customers interact with in order to process purchase or sale transactions. The m-commerce application should usually reflect effectiveness as its counterpart on PC, if there is any.

5. **M-Network Connection**
   In order to avoid user dissatisfaction, the network plays an important role. Users that are used to the Internet expect a good running network, with good responsiveness and performance as on computer.

4 Stakeholders and Requirements Engineering

Devoted to the requirements engineering, this chapter starts by pointing out the various types of stakeholders affected by our solution being developed.

The next section describes all activities that encompass the eliciting and analysing process of requirements.

Do the Bayam Sellam practitioners make use of the mobile devices every day to support their activities? Why and how are they using the mobile technologies? How old are the devices? Do the practitioners feel ready to invest for new devices? These are some important questions that the survey addresses in this chapter. The survey aims to define both the vision of the prototype being developed and the product requirements, including both functional and non-functional requirements.

The overall data model of the prototype ends this chapter.

4.1 Stakeholders

Known as any party, i.e., "*a person, group or organisation that is actively involved in [the development process of the m-commerce solution], is affected by its outcome, or can influence its outcome*" ([Wiegers 2011], p 489). In our case, we identified the following stakeholders.

The stakeholders include:

- buyers,
- sellers,
- governmental department for price regulation,
- mobile operators and
- Internet service providers.

It is therefore of great significance to know and keep in mind the role of each of the aforementioned stakeholders during the requirements elicitation process, from inception to specification.

4.1.1 Buyers and Sellers (Bayam Sellam)

What is Bayam Sellam?
The term Bayam Sellam is a typical expression belonging to the Cameroonian pidgin language, which might be referenced to the category of lingua franca. It coins from English words "buy and sell". A person who undertakes such an activity is also called Bayam Sellam.

As in many sub-Saharan countries, the resale activity called Bayam Sellam is an increasing informal business. It is an activity born out of the struggle to improve individual or family income. Principal actors are the population, comprising usually women and youths. Less men are involved in this activity. In many African societies, various families are under the responsibility of women who have to provide the social needs in terms of food and healthcare. Thus, this activity plays a distinguished role by affording these people the opportunity to run business, even though it is informal.

Referring to the Bayam Sellam activity, buyers and sellers are people partaking to this activity. They play an alternate role. They are buyers when acting in the rural and suburb areas and sellers in the urban areas. Furthermore, people that buy products offered in the urban areas belong also to our stakeholders group. They play the buyer role. Two roles are important for the m-commerce solution we are suggesting, the role played by the (re)sellers and the one by the buyers in the urban areas.

How do they (Bayam Sellam) operate?
This activity consists of buying products at the lowest possible price from various rural trading grounds like markets in hinterland, plantations, road junctions, etc. and retailing them with profit in urban areas. Bayam Sellam are regularly on the move between the rural areas to buy and the urban areas to sell. They operate individually and mostly get together only in delicate business ventures where risk is high. So, even though they operate as individuals, there exists a sort of solidarity among the group which gives them a common identity. They readily assist one another through mutual understanding.

In the majority of cases, the buyers purchase dry and fresh foodstuff from the surrounding rural areas and resell them in the urban areas. The products might also include other stuff. Typically, the resellers get up very early before sunrise and come back after sunset. In addition to their familial responsibilities, they face a lot of challenges. Sometimes they spend nights in the suburbs due to the quality of the transport means and roads that are mostly bad and also insecurity is another obstacle to surmount. Moreover, they use subsidiary transport means such as the head, rickshaws, wheelbarrows, etc. to bring their goods near the road where they may have an appropriate means of transportation. Another risk of this activity is that they are sometimes assaulted and robbed of their money.

In 2004, the Bayam Sellam created an organisation ASBY that provides trainings, sensitisation, microcredits, etc. to its members. ASBY acts throughout the whole country. It is not exclusively limited to Bayam Sellam but to all operators involved in the informal sector such as taxi drivers, fishermen, farmers, call-box holders, etc.

How does the traditional market work?
In rural areas, there are market days. Generally, a market day is a weekly fixed day for holding a public market. On these days, diverse products are purchased. Not sold products are brought back and kept for the next market days. Actors may also move from one market to the next one taking place in a neighbouring locality. At the traditional market places, Bayam Sellam often face the lack of information such as product availability, prices, etc. while conducting their commercial activities on the markets. Therefore, products are often sold without any trustful information concerning, for instance, the actual price.

How could the mobile device support the Bayam Sellam activities?
Involved in this arduous remunerative activities (selling and buying), Bayam Sellam struggle to use their phones for supporting their daily activities. They rely mostly on the common services like short calls, Bip Me / Call Me Back, or SMS. Being users of mobile devices, Bayam Sellam would expect to drive advantages from the mobile usage. In fact, on the one hand, we have to notice that user-oriented applications are almost not available in Cameroon. On the other hand, besides the existing technological infrastructure, the access - via mobiles - to worldwide services like Internet is not only few but the bandwidth associated to its is considerably low, therefore leading to unexpected high cost of Internet services. The high cost constitutes a hurdle that hinders the spread of Internet usage.

In fact, the above mentioned limits connote that the mobile infrastructure solely is not sufficient. If user-oriented Internet services and applications exist or are developed, they should consider the bandwidth as far as it is a crucial parameter for a suitable connectivity with the purpose of data exchange. Consequently, to make practical steps towards the enhancement of the use of the existing infrastructure, we turn the m-commerce into a reality by suggesting a locally adapted m-commerce solution, which is convenient to the Bayam Sellam activity.

We retain, resellers might drive benefits from the m-commerce service by publishing information on product availability, enlarging the range of their potential customers and keeping in touch with them, while buyers might easily be notified of when, where and which products are available in their grasp.

4.1.2 Governmental Department for Price Regulation

In Cameroon, the department of price control, weights and measures is responsible for standards, testing, labelling and certification issues. This department ensures that all metrological activities do conform with the laws and regulations. Presented from the point of view of pricing, even though the Bayam Sellam market shall regulate itself, the m-commerce solution shall ameliorate the legal metrological work by providing useful and up-to-date data on the actual good prices, helping the decision makers for their metrological activities.

4.1.3 Mobile Operators

The mobile operators belong to the group of stakeholders, because they provide a mobile network including diverse mobile services such as voice services, Internet, SMS, MMS, etc. In fact, the mobile network offered by the mobile operator is part of the basic equipments for running the m-commerce solution. The implication of mobile operators in implementing satisfying mobile solutions for mobile users, may be conducive to drive more potential mobile subscribers.

4.1.4 Internet Service Providers

Other Internet Service Providers such as RINGO, YooMee, etc. intervene in the process in such a way that they provide an Internet access or host online database for product information. Used for data synchronisation, the database is the interface between the resellers and the buyers.

4.2 Requirements Elicitation

Recalling the essence of requirements, Sommerville and Sawyer ([1997], p. 4) state:

> *Requirements are ... a specification of what should be implemented. They are descriptions of how the system should behave, or of a system property or attribute. They may be a constraint on the development process of the system.*

The requirements elicitation is an activity of studying user needs aiming to define and record software requirements ([IEEE 610.12-1990], p. 62). Accordingly, to elicit the requirements of the application being developed, we focused on the Bayam Sellam activity in the region of Adamawa [1], notably the city of Ngaoundéré [2]. The motiva-

[1] Also called Adamaoua in French

[2] Capital of the Adamawa region, with 1,1 million population in 2010. Its regional airport is not yet reopened to commercial traffics.

tion for the choice of this city is that it is a typical hub for commercial activities in Cameroon. This is due to its railway station (starting from Douala - a port city - and ending in Ngaoundéré), which is mostly used for goods transportation. Ngaoundéré is the cross-way of both country sides, north and south, and two commercially important neighbouring countries rely on its strategic position for transportation, namely Chad and the Central African Republic.

With the purpose of building good relationships over many day-to-day interactions, we first proceeded by observing the Bayam Sellam activity as a whole in 2011. With the rapid emergence of new media, we were also keen to know whether the mobile devices in particular are used to support sale activities. During the observation period, chats, interactive dialogues through open discussions are organised in order to let Bayam Sellam reflect their experience in their own words.

Finally, we provide a questionnaire as a well-known technique for gathering information and user opinions. The benefit of using a questionnaire is its potential to reach a very wide audience. Furthermore, questionnaires are not arduous to administer and can be analysed within a reasonable time [Marsden 2006].

We designed a questionnaire with nine questions and corresponding answers aiming to elicit, record, and collect information on the stakeholders behaviour and experience while using their mobile devices to perform various tasks, which are mostly related to sale activities. Each answer has a scale with seven options, ranged mainly from *less* or *never* to *very much* or *always*. As far as the questionnaire is concerned, we defined open and closed questions as well. The full list of questions is in Appendix C. In general, the key findings focus on the answers covering the following main domains of activities:

1. **Family**; it measures to which scale, from *less* to *very much*, people involved in the Bayam Sellam activity utilise their devices for closely related family purposes (voice services, SMS to relatives, beeping, etc.).

2. **Business**; scaled from *less* to *very much*, the answer shall reflect the extent to which mobiles are used for supporting business activities (purchase, sale, marketing, distribution of goods, etc.)

3. **Use of SMS**; scaled from *never* to *always*, the answer shall provide an approximate judgement of the use of SMS.

4. **Age of mobile phone**; the phone age should reflect an estimate of phone features that can support different types of applications such as applications runnable on old or new devices, web, GPS or bluetooth apps, etc., knowing that improved technology drives the evolution of mobile phones. The seven levels of the answer are scaled as follows: $>$ *7 years*, ca. *6 years*, *5 years*, *4 years*, *3 years*, *2 years*, and $<$ *1 year*.

5. **Internet access via mobile**; here we estimate the scale of accessing Internet via mobiles, ranged from *never* to *always*.

6. **Fun and games**; the scale from *less* to *very much* estimates the use of mobiles for having fun or playing games (calculator games, Tetris, Solitaire, etc.)

7. **Education**; it delivers the scale, from *less* to *very much*, to which the mobile users express what the have experienced with their devices to perform training activities (vocabulary, reading, writing, mathematics, etc.) that will have any formative effects on their skills and habits.

8. **Investment in mobile device**; this intends to estimate the investment willingness in mobile devices (*no* or *yes*) for supporting daily business activities and the amount (from $<$ *10,000 F CFA* to $>$ *100,000 F CFA*) every three year. According to Sharpe (2005), an average working life of a mobile phone is estimated to seven years but worldwide the average time for user to change his mobile is 11 months.

Dependent on the ability users have to influence the scale of options, we classify the above listed domains into two different groups, i.e., influenceable and non-influenceable domains. Except the *Age of mobile phone*, which is classified as non-influenceable, the other domains can be influenced by the consumers within the realms of possibility. Thus, the influenceable domains include *Education*, *Family*, *Business*, *Fun and games*, *Internet access via mobile*, *Use of SMS*, and *Investment in mobile device*.

4.3 Data Analysis and Interpretation

We conducted the interview with 250 Bayam Sellam in Ngaoundéré. The interviewees - men and women - are involved in various commercial activities, which are their principal source of revenue. The overall results are summarised in Table 4.1. To analyse and interpret the results of the survey, we attribute the digits one to seven to the seven levels of each answer. For each digit we determine the number of answered questions. Doing so, we assign a certain weight to each answer option. These weighted responses provide valuable insight into the dominant sectors regarding the way in which the use of mobile infrastructure can affect sale activities.

To better reflect our results, we will add another level to our previous defined seven levels. The new level contains the number of Bayam Sellam who left the question unanswered. It is represented by the column with the headline zero (0).

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**from 0 to 3**	**from 4 to 7**
Family	10	1	17	8	12	38	84	80	**36**	**214**
Business	3	29	22	22	26	28	61	59	**76**	**174**
Use of SMS	3	74	22	29	25	26	30	41	**128**	**122**
Age of mobile	1	59	14	15	17	32	54	58	**89**	**161**
Internet access via mobile		136	8	2	22	25	15	42	**146**	**104**
Fun and games	6	138	14	19	14	13	20	26	**177**	**73**
Education		165	21	12	8	6	21	17	**198**	**52**

Table 4.1: Bayam Sellam survey by options and answers, 2011

In Table 4.1, we build two significant batches, corresponding to the two last columns. The first batch sums up the the scale from level zero to three. This portion is negligible, because it encompasses those Bayam Sellam who have never participated or are less participating in the corresponding domain or activity. We call this portion the inactive batch, while the other portion starting from the level four and ending at seven is the active batch. It encompasses users who are more and more involved in the corresponding above-mentioned domain, from moderately to very intensively.

The number of Bayam Sellam ready to invest with the expectation of a worthwhile result are recapitulated in Table 4.2, according to the investment range.

Investment range	**Bayam Sellam**
no investment	13
$<$ 10,000 FCFA	24
between 10,000 and 20,000	96
between 20,000 and 30,000	56
between 30,000 and 50,000	49
between 50,000 and 70,000	4
between 70,000 and 90,000	3
between 90,000 and 100,000	2
$>$ 100,000	3

Table 4.2: Bayam Sellam survey acc. to investment willingness, 2011

Obviously, keeping in touch with the family was the most popular response, with 85.6% of the responses grouped in this domain. But very important for us, from the 250 interviewees, 174 (ca. 69.6%) are ready to conduct business activity via mobiles. This represents the second largest category of response. Considering the user scepticism and reticence in Ngaoundéré as in many Sub-Saharan African countries, this number is considerable enough to serve as a stimulus for conducting business over the Internet and to grab the attention of other users. Therefore, this group can act goal-oriented to

enhance the use of the mobile infrastructure through appropriate services. However, those who have never access the Internet gave the following comments:

- Lack of information or training.
- No necessity for now.
- High cost.

The active portion still accounts 104 of the total number of survey respondents, while the inactive has 146 whereas 136 have never access the Internet via their mobiles (Table 4.1).

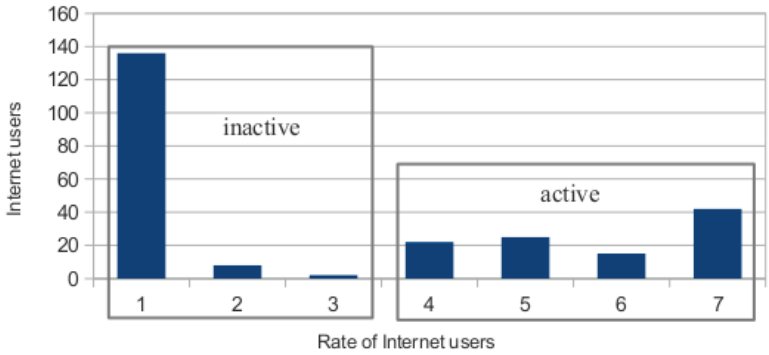


Figure 4.1: Answers acc. to Internet access via mobile

Besides the high cost, the above reasons forebode that many people have not yet discovered the importance of accessing the Internet to improve their work. There is a gap between the Internet as a network and the mobiles held by the Bayam Sellam. This gap is characterised by the lack of contextual and attractive content that can drive the users to go online. Despite the fact that 237 from 250 are ready to invest in different range for mobile phones; assuming that they are equipped with the appropriate applications whose use can achieve improvements for their working conditions.

237 respondents are ready to invest for new mobile phones in general, assuming that they are equipped or will support appropriate applications for the achievement of daily needs. According to the average working life of a mobile phone, our interview has shown that 161 Bayam Sellam have phones that are less than or equal to four years old, whereas 58 Bayam Sellam - almost 1/4 - declared that their phones are less than one year old. Prospectively, all these new phones have the capability to support new applications.

Taking into account that a cheap web-enabled smartphone costs currently around 30,000 F CFA (ca. 45 EURO), we therefore enumerate 114 potential Bayam Sellam that may invest for new phones. While analysing the gathered information, this number tends to include the Bayam Sellam (88) that hold old or obsolete phones and are willing to change if they can take considerable benefits of up-to-date devices.

As key highlights from this analysis, we conclude that 174 (69.6%) Bayam Sellam are ready to use their mobiles for supporting their activity, 104 (41.6%) can do it via Internet and finally 114 (45.6%) are ready to purchase new devices, assuming that they provide the appropriate applications. These facts guide us to develop a vision for an appropriate m-commerce application.

4.4 Vision of a M-Commerce Application

Considering the Bayam Sellam demand, we suggest an innovative application that is simple, user-friendly, easy to install and to update. We build a mobile hybrid commerce application, called **Bayasella** (from Bayam and Sellam).

The vision of bayasella is to provide a m-commerce solution aiming to be adapted to the existing behaviour of using mobile technologies in the midst of the rural and suburb populations.

Indeed, the Bayam Sellam is a strong mixed group, and therefore the following reasons made the elicitation process difficult. These difficulties are similar to those that developers usually encounter while gathering application requirements. We summarise them as:

1. some interviewed stakeholders have different interest and understanding of application requirements;
2. several of them do not know what they want from a mobile device except receiving calls;
3. they encounter difficulties to articulate what they want their mobile to do;
4. some tend to make unrealistic demands.

Bayasella is a m-commerce application. Described as a mobile-facilitated application, which enables ordinary users to suggest products for sale (done by the sellers) and to find products for purchase (done by the buyers). It is a third party solution that supports the consumer-to-consumer (C2C) business process. Based mainly on mobile web technologies (HTML5), the system will store product details offline, and synchronise them with the online database whenever the user wants. The online database acts as an interface between buyers, sellers and government officials. Unlike the advertisement strategies such as sending SMS message, calling friends, shouting at a street corner, bayasella is innovatively developed to support and increase the utility of existing mobile infrastructure and to fulfil the demand of mobile phone consumers involved in commercial activities.

A further objective is to build progressively a virtual adapted market place where people can offer products to sell and find products to purchase, using requiring low resources. The Bayasella solution is designed to inspire, and be useful for all those conducting commercial activities. Prototypically, it shall provoke the efficient and effective use of the existing mobile infrastructure.

Bayasella includes the following important activities, which are the offering, publishing, marketing, advertising, finding, and buying product. Figure 4.2 shows the different product-based steps of the application.

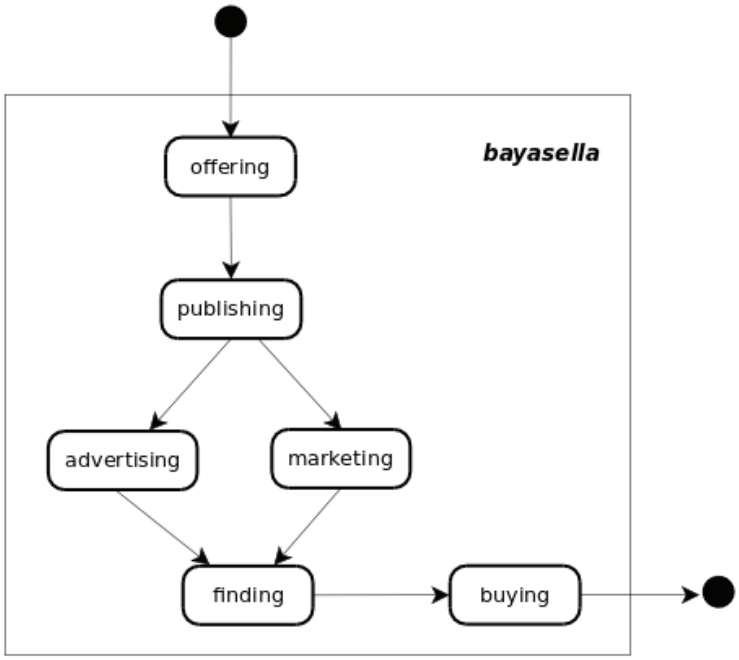


Figure 4.2: Product-based steps

The triggering event is the intention of product sale; the *offering* step deals with the product entries, it checks all integrity constraints linked to the storing process. Then the product is published (synchronised) via a script with a distant database. The task of the *advertising* and *marketing* step is to set the product ready for the potential buyers. Finally, the *finding* step gets the suitable products from the database according to search criteria defined by the buyer who proceeds with the purchase process offline using the *buying* component.

4.4.1 Motivations for Bayasella as a Hybrid App

The existing mobile infrastructure in Cameroon and the way people tend to use their mobiles provide a suitable environment for introducing hybrid apps. The reasons may

be summarise as follows:

- the bandwidth is low and unreliable,
- the Internet cost is high,
- users can work offline if the Internet connectivity becomes low and frustrating,
- the code portability and optimisation is high according to the hosting mobile device.

The suggested application shall be accessible to all mobile users, regardless of their mobile network or operator.

4.4.2 Influence Factors

We generally refer to the influence factors as concerns that specify restrictions or special conditions for the architecture. As it is common in the software engineering discipline, there exist factors that influence the deployment of new applications negatively or positively as well. The design and architecture of Bayasella relies substantially on four influence factors, which are described as:

1. **Application features and attributes** shall fulfil the user requirements, this means broadly to process the product data from the seller, through the exchange interface, to the buyer.
2. The surrounding technical infrastructure and the available software and hardware, those factors are **technological factors**. Here, it is question of existing mobile infrastructure, the operating mobile environment and how our app can fit into the surrounding environment. Also, this factor plays a major role. Since we intend to develop a hybrid application, web-enabled devices are required and also Internet accessibility for data synchronisation.
3. Furthermore, the skills and experience of the individuals involved in the development process are significant factors. These factors are **personal factors**.
4. Finally, there are **organisational factors**, which include, for instance, the governmental department of price regulation, the Internet providers. These parties influence the architecture, as far as they are part of the stakeholders.

4.5 Bayasella Requirements

Typically, functional requirements describe the software functionality and behaviour, while non-functional requirements specify the properties like security, usability, performance, and so on. The distinction between functional and non-functional requirements

is not always clear. Because non-functional requirements usually set some restrictions on the product being developed, they can be changed into functional requirements depending on the factors such as developer's experience, the comprehension of the application domain, or how important the requirements document shall be either to users or developers.

As during the development process of any software, we need to understand the behaviour of the system to be developed by describing the functionalities.

To identify and define the functional and non-functional requirements, we rely on common techniques, which consist in defining the use case diagrams of the overall system.

4.5.1 Use Cases

From the user perspective, the following use case diagrams determine the overall Bayasella functionalities. It represents the application functionalities in form of user's interaction with the application. Sellers, buyers and government officials initiate corresponding interaction for achieving a certain goal and getting benefit of it. These actors of the system are called primary actors. Offline and online database, and Local Storage participate in the completion of tasks initiated by the primary actors; they are classified as secondary actors. The secondary actors do not benefit from the accomplished tasks.

To hit a better overview of the representation of user's interaction, two use case diagrams are suggested. The first diagram shows the entire functionalities when the application works in offline status, while the second one presents the functionalities executable in online status.

As far as the application is operating offline, we determine the following primary and secondary actors, and the corresponding use case diagram.

The primary actors

1. Seller
    - enters product details.
    - sorts products.
    - deletes product.
    - changes product status.
    - enters market places and places of interest.
    - enters resellers.
2. Buyer

- deletes product.
- changes product status.
- sorts products.

The secondary actors

1. Local Storage participates in
   - storing product data locally (reseller and market place or place of interest, which are preselected while entering the next product).
2. Offline database participates in
   - storing product data locally.
   - storing reseller locally.
   - storing market place or place of interest locally.

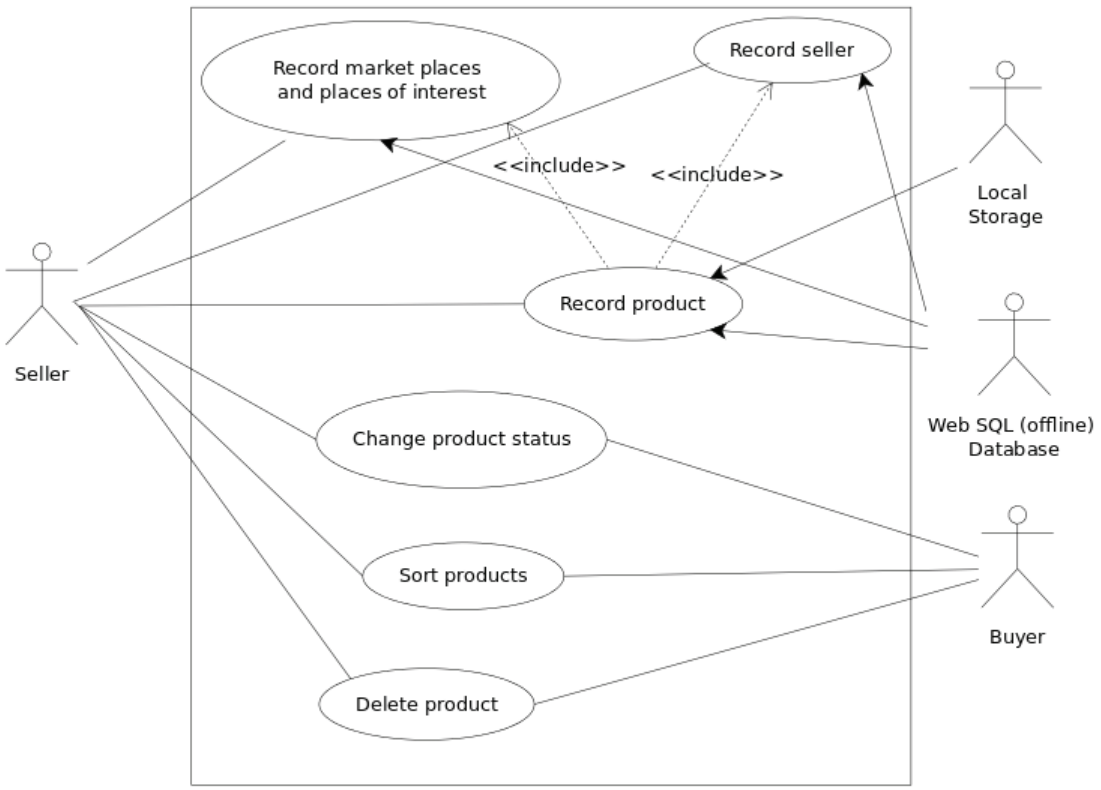


Figure 4.3: Use case diagram for offline status

When operating online, we distinguish the following primary and secondary actors, and the corresponding use case diagram.

The primary actors

1. Seller
    - uploads product.
    - views downloads.
2. Buyer
    - downloads product.
3. Government officials
    - extract product details.

The secondary actors

1. Online database participates in
    - persisting product data (up/downloading and extracting products) on distant database server via an Internet connection.
2. Offline database participates in
    - persisting downloaded product data locally.
    - persisting download views locally.

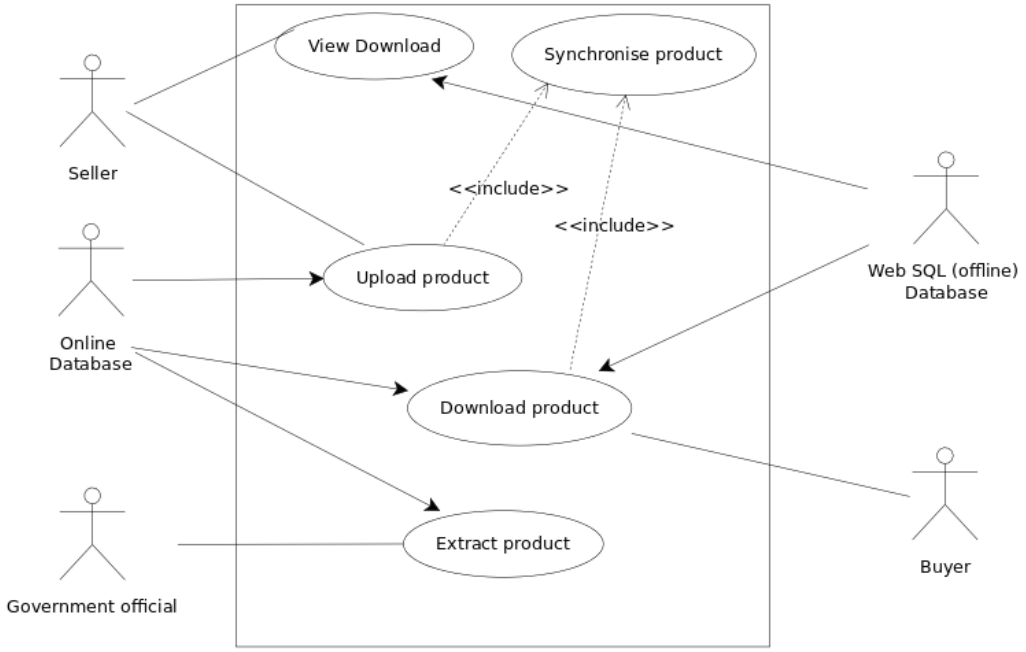


Figure 4.4: Use case diagram for online status

The feasibility of the scenarios presented in the diagrams depends on the satisfaction of the subsequent functional and non-functional requirements of the mobile commerce application.

4.5.2 Functional and non-functional Requirements

In the requirements description, the term *product synchronisation* or *synchronisation* used in relation with sellers and buyers means *product uploading* and *product downloading* respectively.

In order to leverage the Bayam Sellam demands in more effective requirements of the application being developed, we benefit from the questionnaire analysis done with the 250 Bayam Sellam to get good acquaintance with the marketplace situation. In the undermentioned requirements list, functional requirements are labelled with FR and non-functional with NFR.

We divided the functional requirements into two groups: offline and online.

Offline requirements
The offline requirements are functions that the user can execute in the absence of Internet.

- **FR1:** Seller records product data and the application shall display the product details (name, description, price, and product category), including seller's data

(name and phone number) and market place. Thereby the status *open* is assigned to the product.

- **FR2:** The application shall preselect the last reseller and the market place as well.
- **FR3:** Sellers shall sort the product list according to the four different criteria: *open*, *sold*, *synchronised* [3] or *all*.
- **FR4:** Seller shall change product status from *open* to *sold*.
- **FR5:** Seller shall change product status from *synchronised* to *sold*.
- **FR6:** Seller shall delete products.
- **FR7:** Buyer shall mark product as *bought*.
- **FR8:** Buyer shall delete products.
- **FR9:** Buyer shall sort the product list according to the different criteria: *wish list bought* or *all*.
- **FR10:** Seller and buyer can check the presence of Internet.

Online requirements
For the fulfilment of the online requirements, an Internet connection is indispensable.

- **FR11:** The application shall display the number of items uploaded during the synchronisation process with the online database. This feature is executed by the seller.
- **FR12:** After the synchronisation process, the application shall change the product status from *open* to *synchronised*.
- **FR13:** Seller shall view the number of downloads for each synchronised product.
- **FR14:** The application shall display the number of products downloaded by a buyer, according to a product category, market place or time frame previously selected.

The non-functional requirements describe restrictions on Bayasella and its development process, and specify external constraints on the behaviour of the application. We summarise the non-functional requirements as follows:

- **NFR1:** Seller shall run the application offline.

[3] The status *synchronised* is indicated in the online requirement FR12

- **NFR2:** An Internet connection must be available for the synchronisation of the offers.
- **NFR3:** A sudden lost of Internet connection shall not lead to data incoherence.
- **NFR4:** A relational database shall handle the data persistence.
- **NFR5:** A Web Server shall take care of the synchronisation (up/download) process.
- **NFR6:** The synchronisation script must generate offer data in a format that can be used as an exchange interface between the online database and the mobile device.
- **NFR7:** The application shall support the principle of delta encoding or data differencing during the data synchronisation (up and download).
- **NFR8:** The application shall run on web-enabled devices (e.g., Android platform using the integrated Webkit engine).
- **NFR9:** The application shall display informative error messages, for instance, when the user leaves mandatory fields (e.g., product name, seller name, etc.) empty or enter unauthorised data format (e.g., no alphanumeric data or letter for phone number).
- **NFR10:** The governmental department for price regulation shall generate structured product data from the online database in a format that is easy to be integrated in other applications and processed.
- **NFR11:** The application shall provide the possibility for checking the Internet connection explicitly.

4.6 Data Model of Bayasella

The data model of Bayasella defines how the data will be structured to meet the Bayam Sellam's information needs. This modelling process characterises the logical design of the database, which aims to identify the relationships among the data items and grouping them in an orderly fashion ([Stair and Reynolds 2012], p. 185). One of the most widely applied modelling approach is the one proposed by Peter Chen (1976), and known as the entity-relationship model. It comprises techniques used to describe a data model in an abstract way. Hence, the data model shows the data *entities*, their associated *attributes*, and the *relations* between these entities.

The author of this model described:

> *The entity-relationship model can be used as a basis for unification of different views of data: the network model, the relational model, and the entity set model.*

> *Semantic ambiguities in these models are analyzed. Possible ways to derive their views of data from the entity-relationship model are presented* ([Chen 1976], p. 9).

Indeed, the bayasella model is composed of five entities, which are:

1. **Product**; it represents the good to be sold. Its attributes are *ID*, *name*, *description*, *price*, *date* and *view_counter*.
2. **Status**; it refers to the product status. The property *name* can have one of the following values: *open*, *sold*, *paid*, and *synchronised*.
3. **Place**; it marks a place of interest (POI) or market place where products are to be sold. It is characterised by two attributes: *ID* and *name*.
4. **Category**; it contains the category *name* of the product to be sold, such as fruits, vegetables, poultry, caprine, etc.
5. **Seller**; this represents the person who (re)sells products. He/she is characterised by an *ID*, a *name* and a *phone*.

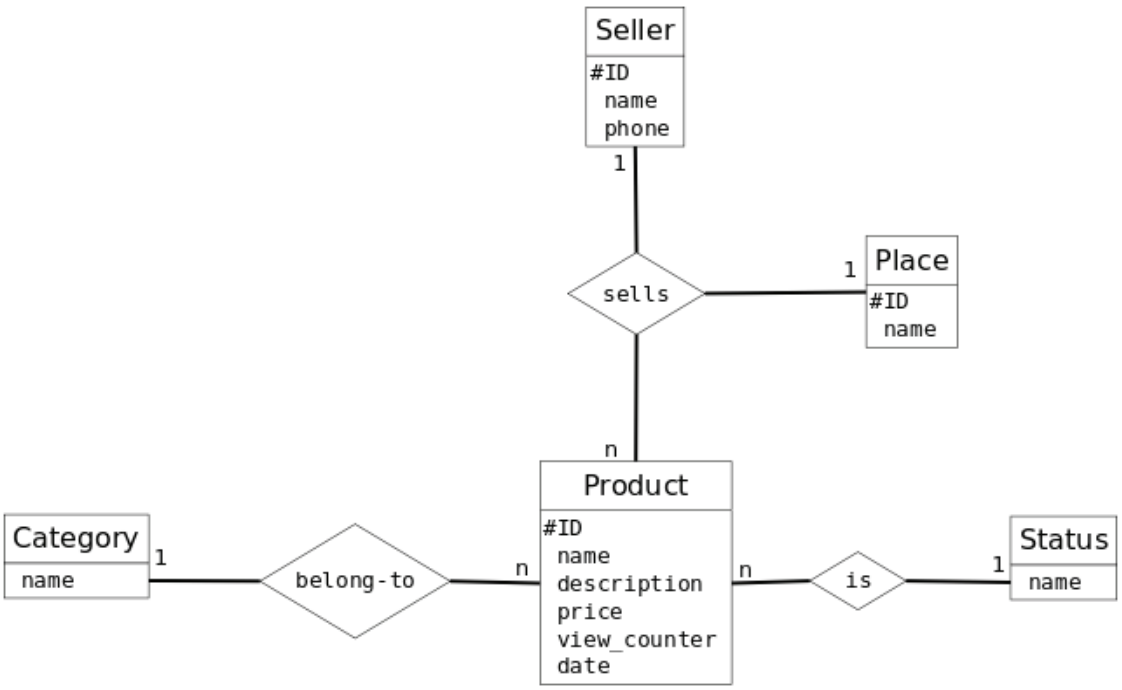


Figure 4.5: Entity model

In the figure above, the entity model presents the entities, the relationships between them, and their cardinality as well.

5 Architecture, Technical Approach and Portability

Aiming to describe the technical approaches used to implement the prototype, this chapter introduces the architecture by focusing on two networks the Global System for Mobile Communications (GSM) and the Internet.

Next, we specify the principle of storing data by means of some technical facilities, either locally (local storage) or on a distance server (synchronisation of serialised data); then follows data serialisation, and global issues concerning local data, such as malicious attacks and performance.

The end of this chapter demonstrates that the underlying architecture of Bayasella can be applied to other areas, which are more or less linked to Bayam Sellam activities. For instance, an architecture for combined weather references comprising data from an existing weather forecast system and indigenous data from a showcased local ethnic group.

5.1 Bayasella Architecture

Due to its complexity, traditional software commonly requires a deep-structured architecture to break it down in multiple components, while mobile applications are built to be lightweight and as simple as possible. Nevertheless, since the architecture remains the first artefact in the software life cycle describing how we can solve a problem, mobile apps also need an architecture aiming to describe the overall structure, i.e., the components, their relation to each other and also their relation to the environment in which they will operate.

Recalling the results of interviews conducted in Ngaoundéré, the analysis of the collected information has shown that the trend of Bayam Sellam accessing Internet services is increasing. Nevertheless, there are still some Bayam Sellam using SMS to support their business activities. We thus discuss two types of architecture, depending on the model of the communication channel. The first approach is based on SMS, i.e., the GSM, and the second is an architecture for hybrid application, based notably on the Internet network.

5.1.1 Architecture based on GSM Network

GSM is a standard for digital cellular communications; it is used in more than 200 countries by more than three billion people [Stair and Reynolds 2012]. In this approach we want just to focus and to demonstrate that an architecture based on the

GSM wireless network is conceivable. This type of architecture relies on SMS messages. Related to the Bayasella data model, offer data are sent via SMS, containing no more that 160 characters, which constitute the maximal length of each SMS message.

Figure 5.1 shows the different components of this architectural design. The implementation of such an architecture may be done using the Java ME technology. Java ME was developed in order to deal with the constraints associated to the development of applications for small devices. It considers the limited memory, display and power capacity of mobile devices [Java ME 2013].

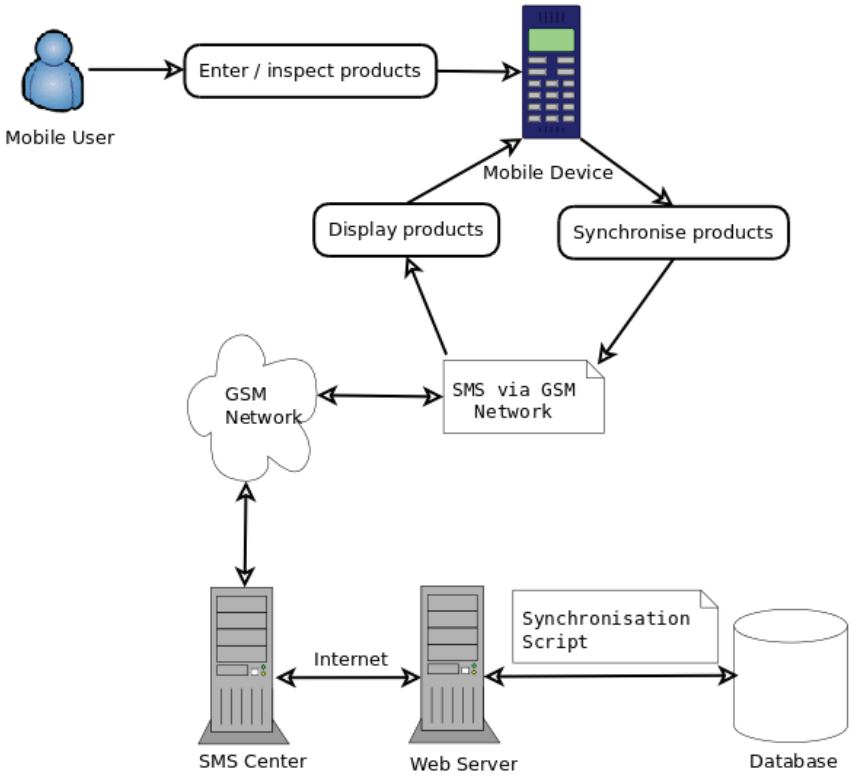


Figure 5.1: Architecture based on SMS and GSM

Description of components

According to the suggested architecture, message senders are product sellers and receivers are buyers.

The **mobile device** participates in the process by sending an SMS containing the product data. At the beginning of this action, we have the mobile user, i.e., the seller. If the user is a buyer, the **mobile device** receives and displays the product data.

The **GSM Network** is the network used to support the digital communication for voice and data services on mobile phones in general. Related to our architecture, it is

used to send and receive product data via SMS services.

The **SMS Center** is the SMS Gateway of the mobile network operator. It contains all SMS messages.

The **Web Server** retrieves data from the SMS Center via Internet by means of SMS protocols such as Short Message Peer-to-Peer (SMPP), Computer Interface to Message Distribution (CIMD) or External Machine Interface (EMI) as an extension of Universal Computer Protocol (UCP), and the receiver's number.

The **Database** (MySQL, Oracle, Microsoft SQL Server, etc.) contains the parsed product data and the data of product receivers as well.

A typical product synchronisation process using the aforementioned architectural approach would go like this:

1. the seller enters the product data in the mobile device, using the Bayasella SMS app
2. the seller sends the product data via SMS to one or more numbers registered as receivers;
3. the data is stored on the SMS server of the mobile network operator;
4. the Web server retrieves the data from the SMS server;
5. the product data are persistently stored on the product database;
6. then the subscribed buyers receive the product data forwarded by the Web server.

Although this architecture is based on the SMS service, which belongs to the core services of mobile communication, its presents diverse weaknesses that may expressively limit the efficient use of this solution. We summarise them in the following points:

1. Captured as SMS message, the product details are neither appropriate to parse nor suitable to be integrated in a database as structured product data, in particular when it comes to data retrieval operations.
2. SMS messages have a limited length of 160 characters; this restricts enormously the product description and other data belonging to the data set.
3. If a seller wants to submit many products, he/she has to send several SMS messages. Thus, this is effort-intensive (time, cost, etc.).
4. Because this solution is SIM-dependent, it requires signed contracts with a GSM service provider, which furnishes access to the SMS Gateway. Such contracts are usually expensive.

Altogether, the architecture based on GSM presents some weaknesses that will limit its efficiency. Therefore, scrutinising a more eligible architecture is necessary.

5.1.2 Architecture based on Internet Network

Designed as a hybrid application, the second architecture is based on Internet network exclusively, using HTTP as the foundation for data communication. Figure 5.2 shows the overall architectural components. The development of such application is possible through the combination of technologies such the cross-platform HTML5 and Java.

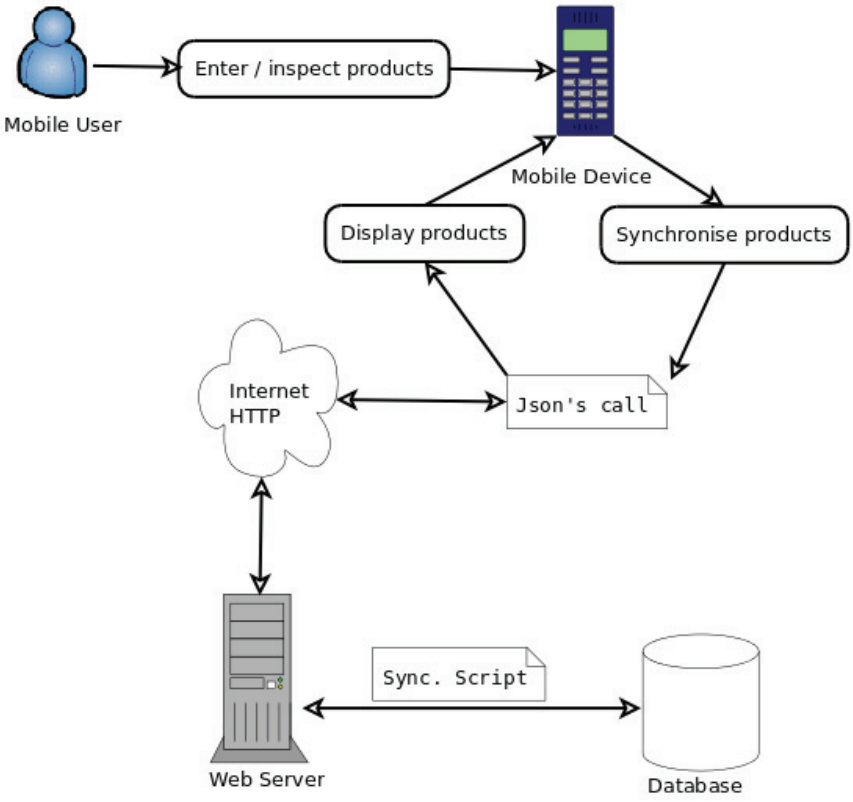


Figure 5.2: Architecture based on Internet network

Description of components

Equipped with the hybrid application, the **mobile device** is used by the Bayam Sellam actors to initiate any activity aiming to synchronise products.

The **JSON call** is an API that converts the data of the offered products in a JSON format and places them at the disposal of the Web Server. Compared to the XML API, the JSON API consumes less resource.

The **Web Server** is the component that receives or sends the product data via HTTP requests from or to the WebKit engine of the mobile device. It forwards the data to the database or retrieves data from it.

The **Sync. script** is a component that synchronises the database. It plays a twofold role. On the one hand, it generates product data to be downloaded in JSON format, and on the other hand, it extracts data to be uploaded from JSON format.

The **Database** (MySQL, Oracle, Microsoft SQL Server, etc.) save the uploaded offers entirely.

A typical product synchronisation process using the hybrid approach would go like this:

1. the seller enters the product details via the m-commerce app;
2. the user (seller or buyer) synchronises the products via a JSON script (Internet via HTTP protocol);
3. the Web server processes the product data from the JSON format;
4. the product data are stored on the Bayasella database.

Considering the following reasons and having in mind the limits of the architecture based on SMS and GSM, we will implement only the solution based on the hybrid approach:

- the number of Internet users is growing in Cameroon;
- users deal with a more reliable Internet connectivity;
- compared to the cost of multiple SMS messages, the overall cost of Internet connection will remain low;
- we want to focus on Web technology as a future technology;
- the Web technology is flexible in terms of development and maintenance as well;
- the hybrid approach is portable to other platforms, with low effort;
- the infrastructural cost is low and network latency is less;
- in regard to resource consumption, for instance the performance, the JSON API is suitable and consumes less resources;
- users work offline, most of the time;
- the MCTs being launched by the government may become important access points;
- sellers can upload one or multiple products at once when the network is available or reliable;
- buyers can download one or several products at once when the network is available or reliable.

To illustrate the input-process-output of the application, we depict the processing of product data. For the visualisation, the data flow diagram (DFD) would best meet our purpose. In fact, the DFD shows the different actors that intervene during data processing, as it is pointed out in the following diagram 5.3. Sellers, buyers initiate diverse processes that lead to changes of product data in the data store. Four symbols are used to represent the different components of the diagram:

1. Squares denote external entities, which send or receive data (e.g., *Sellers* and *Buyers*).
2. Rounded rectangles represent processes, which receive data as input, work with it, and output it (e.g., *Upload Product* and *Add Product*).
3. Arrows represent the direction of data flow (e.g. arrow indicating the action of adding a new product data, starting from the entity *Sellers* and ending in the process *Add Product*).
4. Open rectangles represent data stores (files or databases) that participate to the process when the product data undergo changes (e.g. *Online bayasella Database*, *Product Price File*).

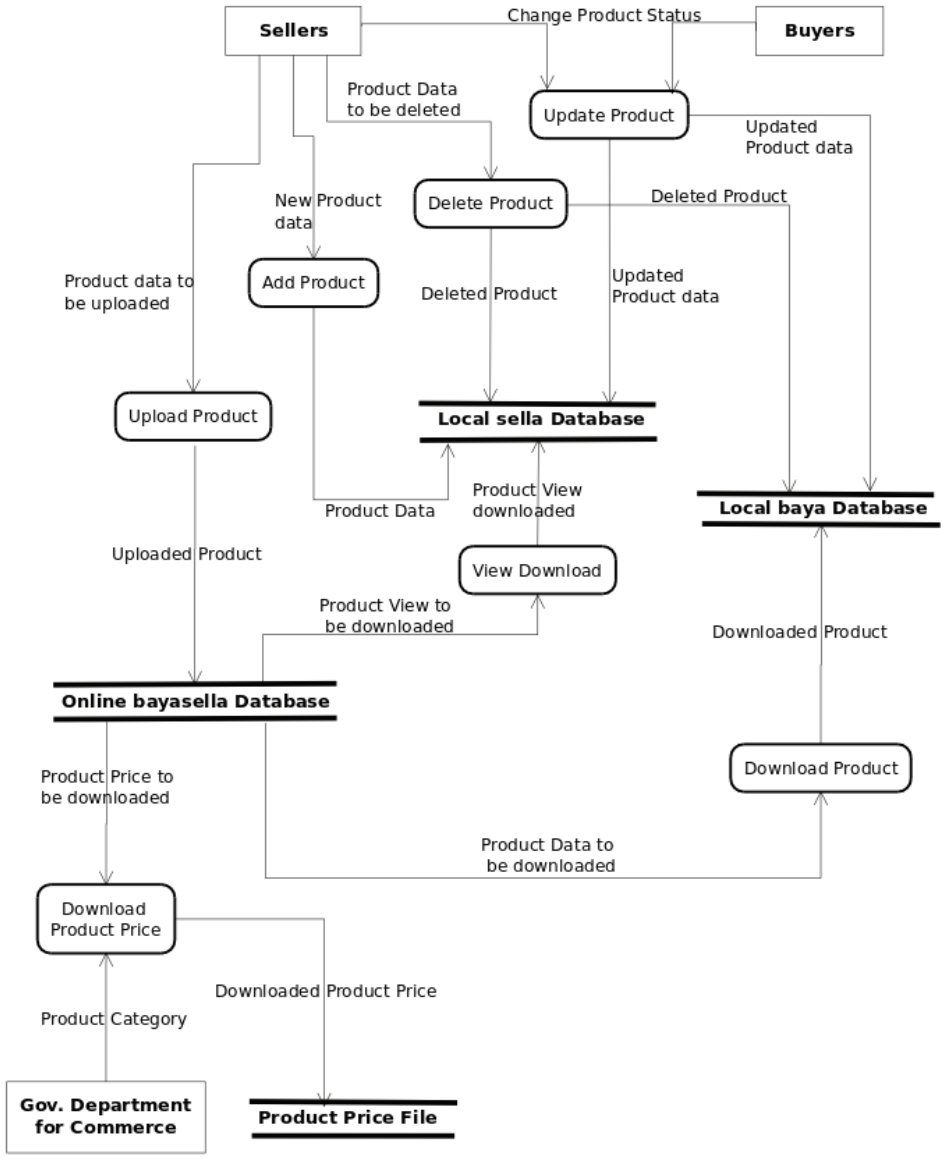


Figure 5.3: Data flow

5.1.3 Mobile Information Architecture

Mobile information architecture is all about the way of organising data within an informational space, i.e, the screen of a mobile device. It is characterised by usability attributes like intuitive, simple, findable, usable, and so on [Fling 2009]. When we consider the mobile interaction opportunities: input-depending keyboard layouts, gesture-based interactions, camera, and voice, in addition to other characteristics such as screen size, connectivity, etc., the information architecture becomes a determining factor for navigating through the application. As a matter of fact, we must deal with information design and ordering data on the interface, i.e, how information should be

structured, organized, labelled, and identified on the mobile user interface in such a way that the navigation will turn out to be satisfactory. For that we follow existing heuristics, standards, and styles of design.

Similar to mobile Web apps, we adapt the information design as shown in Figure 5.4, comprising three important areas or components:

- The header, containing the app name, a link to the start page, the headline of the current content.
- The content, an area containing the current content.
- The combined footer and navigation, indicating the navigation items displayed according to the actual content.

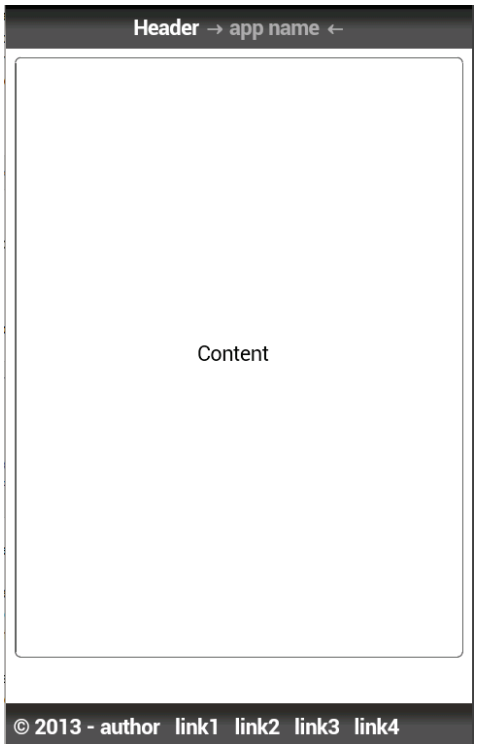


Figure 5.4: Overall Bayasella information architecture

Finding answers to the questions where and how to place information means we are thinking about the topic of interaction design. It is all about designing user interface that satisfies the needs and desires of the people who will use the application [Hoober and Berkman 2012]. Thus, while WIMP (Windows, Icons, Menus and Pointer) was the fundamental interaction principle for systems running on PC, the counterpart applications for mobile devices rely on Windows, Icons and Menus as well and the Pointer is replaced by the touch (finger) function. The design process of mobile applications is characterised by some attributes summarised in Table 5.1, and classified as factors that influence the development of mobile applications. The table list compares attributes for both mobile device and desktop computer.

Smartphone	**Desktop**
Small screen	Big screen
Small keyboard (if present)	Big keyboard
Intermittent connectivity	Reliable connectivity
Low bandwidth	High bandwidth
Battery powered	Plugged in
Touch	Mouse

Table 5.1: Mobile vs Desktop Computer

Since Bayasella will be developed as a hybrid application, we take advantages of the Android's user interface guidelines[1] defining how native apps for Android platform should look like. To a large extent, the same behaviour and design of native apps can be reproduced for hybrid apps using the HTML5 and technologies that pertain to it.

The Android's user interface guidelines specify [Android UI 2013]:

> *Android provides a variety of pre-build UI components such as structured layout objects and UI controls that allow [...] to build the graphical user interface for [...] app. Android also provides other UI modules for special interfaces such as dialogs, notifications, and menus.*

For example, Android's UI provides two layout components for organising items: while the pre-build UI component called ***ListView*** displays a list of scrollable items, the ***GridView*** displays items in a two-dimensional scrollable grid. Figure 5.5 and Figure 5.6 illustrate the two types of view.

Figure 5.5: Android ListView
Source: Android

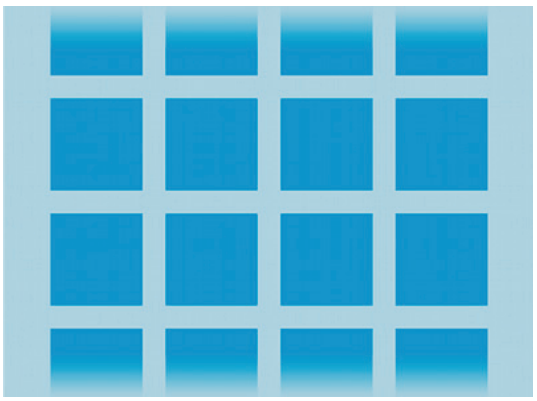


Figure 5.6: Android GridView
Source: Android

[1]There exist user interface guidelines for other mobile platforms such iOS, BlackBerry, Bada and Windows Phone

Among the existing patterns for displaying information on mobile devices in general, two will be retained *Vertical List* and *Fisheye List* [Hoober and Berkman 2012]. The *Vertical List* pattern is the most appropriate for organising and presenting list of items (Bayasella offers). The *Fisheye List* pattern is used for performing drill down functionality, for showing item details within a list of items. Each mobile OS possesses its own pre-build UI components for implementing these two design patterns. For instance, the Android community uses the *ListView* pre-build component for implementing *Vertical List*. Furthermore, comparing these pattern ingredients provided by native libraries with those existing in HTML5, we rebuild the effects produced by them using some counterparts technologies from JQuery library, notably the *ListView* attribute of list items, and the *slideUp()/slideDown()* functions.

5.2 Approaches of local Storage

The mostly offline and less online features of Bayasella are two policies that guide our choice of the technological approaches. Hence, we scrutinise the local storage approach suitable for developing applications that aim to work both online and offline. To pave the way, a short historical background of local storage will lead us to the different combined technologies.

5.2.1 Historical Background

Relying on the persistent local storage, native client applications have held advantages over web applications. Native applications are installed in the corresponding operating system, which typically provides them an abstraction layer for storing and retrieving application-specific data. These data may be stored in the registry, INI files, XML files, or some other place according to the platform convention. If the native client application needs local storage beyond key/value pairs, the developer can embed a database, invent a new file format, or find any other solutions. Historically, web applications have had none of these luxury advantages ([Pilgrim 2010], p. 127).

To be competitive, web application engineers started developing diverse solutions for storing data locally on the client machine. The solutions encompass storage approaches such as Session, Cookies, Web Storage, Web SQL Database, IndexedDB.

The Indexed Database (IndexedDB) has been implemented in Firefox 4.0 Beta and Chrome dev channel exclusively. Due to this limitation, we will not consider it further in this work.

5.2.2 Session and Cookies

Cookies can be used for persistent local storage, which deals with small amounts of data. Cookies data are stored on the hard disk of the client. For instance, we can use cookies to track and store state of a user interaction on Web sites so that when the user logs-off and returns later, she/he can pick up at the previous point. Describing the cookies technologies, Pressman ([2010], p. 336) mentions their controversial aspect.

> *In general cookies can be designed to store state information. However, cookies are controversial technology, and other design solutions may be more palatable [...].*

In addition, the following three deal-breaking downsides are typical to cookies and limit their use:

1. Cookies slow down web application by needlessly transmitting the same data over and over with every HTTP request.
2. Cookies send data unencrypted over the Internet (unless the entire web application is served over SSL).
3. Cookies are limited to about 4 KB of data.

While cookies are stored on the hard disk, a session is available as long as the browser is opened. A session can be defined as a token for interactive information interchange between two of many devices, for instance, between client and server. Programmatically, HTTP session data are temporarily saved on the client side and sent, whenever needed, to the server using the cookies techniques. Session values are good for ensuring and guaranteeing three important security issues: confidentiality, data integrity and authenticity for application users. Unfortunately, the values are available only for the actual session and get lost when the user closes the browser or ends the session.

In a nutshell, cookies and sessions are constraining factors to the efficient use of mobile applications, specially when they have to operate mostly offline and deal with amount of data larger that 4 KB.

5.2.3 Web or HTML5 Storage

Historically, diverse technologies have been carried out to perform Web applications to be competitive as their counter parts from native area. Microsoft started by the development of the so-called DHTML Behaviors, which rely on *userData*. This *userData* technology allows Web pages to store up to 64 KB of data per domain, in a hierarchical XML-based structure.

In 2002, Flash cookies were introduced in Flash 6. The success was limited only to Flash objects up to 100 KB, stored per domain.

In 2006, a Flash-to-JavaScript bridge called AMASS (AJAX Massive Storage System) was developed, allowing to store up to 100 KB per domain. Later the AMASS has been rewritten in to *dojox.storage* (Dojo Toolkit).

In 2007, Google launched Gears, which is an open source browser plugin. Gears provides an API to an embedded SQL database based on SQLite for storing unlimited amount of data per domain. By 2009, dojox.storage could auto-detect Adobe Flash, Gears, Adobe AIR, and an early prototype of HTML5 storage was implemented for older versions of Firefox ([Pilgrim 2010], p. 128).

From these solution attempts emerge another challenge; all of them are either specific to a single browser, or rely on a third-party plugin. Then, Web storage, also called HTML5, solved the problem by providing a standardised API, which consists in a Document Object Model (DOM) mechanism. DOM encompasses a comprehensive means through which Web sites can store named key/value pairs locally, thereby interactive applications can be built. Once the data have been saved, they remain on the computer even after leaving the Web site, closing the browser tab or exiting the browser. The Web sites can access them with JavaScript after the page is loaded. Subsequently, the data are automatically loaded from the same source, i.e, same domain name, protocol, and port. The data are not transmitted to remote Web server like it is the case with the cookies data, unless the user decides to undertake any transmission action. So far, HTML5 provides the best required ingredients for dealing with data stored locally.

The Web storage API relies on JavaScript (jQuery library) mechanism. The two key objects are **localStorage** and **sessionStorage**. The objects are built using a key-value mapping approach. The corresponding interface implements four powerful methods:

- getItem.
- setItem.
- removeItem.
- clear.

The **sessionStorage** objects differ from those of **localStorage** in such a way that they are not available to windows/tabs and the data are discarded when the window/tab is closed.

To us, two important technologies pave the way for mobile Web applications: HTML5 and WebKit. The HTML5 technology refers, on the one hand, to a new version of

the language HTML, with new elements, attributes, and behaviours and, on the other hand to a set of standard Web technologies composed of HTML, CSS3 and JavaScript. WebKit is an open source browser engine, used to render Web applications. WebKit is integrated in the standard browsers of Android, iOS and BlackBerry OS.

5.2.4 Web SQL Database

For persistent data storage, structured SQL relational databases have proved all their power and reliability over years. The Web SQL Database provides us an implementation of relational database on the Web client side. Despite the fact that the W3C has announced that this API is no longer being supported by the developers, there are three fundamental reasons explaining our choice of this technology:

- It is supported by multiple WebKits, in particular those of the leading mobile platforms such as Android.
- Huge amount of structured data can be processed.
- We can process data offline, ideal for mobile devices working in areas where the access to Internet is limited.

Technically, we can summarise the Web SQL Database implementation in three important methods:

openDatabase is used to open/create a database. This method has five parameters

1. *databaseId:* The database ID.
2. *version:* A string identifying the database version.
3. *description:* A human-readable database description.
4. *estimatedSize:* The estimated size of the database (in bytes).
5. *creationCallback:* A callback that will be executed once the database has been opened/created.

transaction/readTransaction is used to open a transaction for the execution of SQL statements. The *transaction* method is used for INSERT/UPDATE/DELETE operations, and the *readTransaction* for SELECT statements. This method has one parameter.

1. *callback:* The callback function is called when the transaction is opened. When the callback is executed, it passes in a single argument for the transaction instance.

executeSql is used to run a SQL statement within a transaction. This method has four arguments.

1. *sqlText:* The SQL statement to be executed.
2. *sqlParameters:* An array of values for the parameters included in sqlText statement.
3. *completionCallback:* A function callback that will be invoked when the SQL statement has been successfully executed.
4. *errorCallback:* A callback that will be invoked if there are issues with the SQL statement or database.

In order to persist Bayasella data offline on the mobile devices, we rely on the Web SQL Database. The code Listing 5.1 illustrates the previous statements leading to the creation of the Bayasella database.

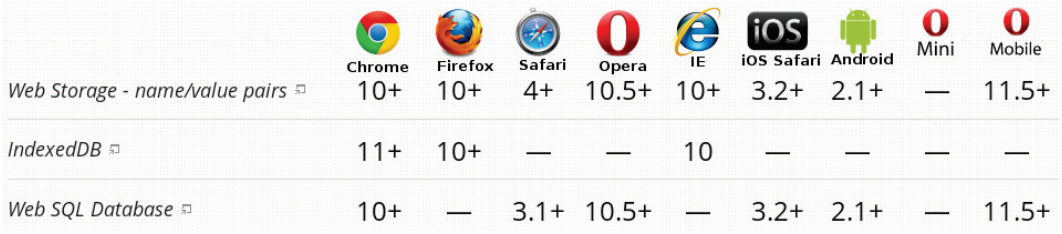
```
try {
 db = openDatabase("bayasella", "1.1", "Bayan Sellam Database", 400 *
     1024);

 db.transaction(function(transaction) {
    transaction.executeSql(
 " CREATE TABLE IF NOT EXISTS product(" +
 " prod_id TEXT, " +
 " name TEXT NOT NULL, " +
 " description TEXT, " +
 " price INT NOT NULL, " +
 " category TEXT NOT NULL, " +
 " phone INT NOT NULL, " +
 " owner TEXT NOT NULL, " +
 " status TEXT NOT NULL, " +
 " important TEXT, " +
 " view_counter INT NOT NULL, " +
 " created DATETIME, " +
 " due DATETIME, " +
 " sold DATETIME);");
 });
}
```

Listing 5.1: Bayasella databasee

5.2.5 HTML5 Browser Support

While Chrome, Safari & Opera, Firefox and IE support the Web SQL Database technology, Mozilla is not supporting it any time soon (Mozilla is philosophically opposed). Figure 5.7 gives an overview of browsers supporting the different HTML5 technologies. The browsers being supported are indicated by their version numbers, for instance, the version 10 of Chrome supports Web Storage and Web SQL Database, while the version 11 supports IndexedDB.



	Chrome	Firefox	Safari	Opera	IE	iOS Safari	Android	Mini	Mobile
Web Storage - name/value pairs	10+	10+	4+	10.5+	10+	3.2+	2.1+	—	11.5+
IndexedDB	11+	10+	—	—	10	—	—	—	—
Web SQL Database	10+	—	3.1+	10.5+	—	3.2+	2.1+	—	11.5+

Figure 5.7: HTML5 technologies supported by browsers
Source: HTML5 2012

5.3 Data Serialization

The *data serialization* is the process of converting a data structure or object state into a format that can be processed and stored by a given system.

In order to serialise and de-serialise the data stored locally, we rely on the *JSON.stringify()* and *JSON.parse()* functions provided by JavaScript Object Notation (JSON) library or the *parseInt()* and *parseFloat()* functions to coerce retrieved data into the expected JavaScript data type, i.e., Integer and Float respectively.

The JSON format is often used not only for serializing but also for transmitting structured data over a network connection. It is also used for data exchange between diverse systems and applications, serving therefore as an alternative to XML.

To synchronise the Bayasella data, we rely on the data serialisation based on JSON technology.

5.4 Global Issues of Local Data Storage for Mobiles

With the mission of defining Web standards and leading the Web to its full potential, the World Wide Web Consortium's (W3C) classifies HTML5 as a work in progress. HTML5 presents some important vulnerabilities, which are scripting attacks and performance.

5.4.1 Malicious Attacks

Assuming that HTML5 is a set of HTML and JavaScript technologies, we can face challenging security issues due to cross-site scripting attacks. Because the approach of local storage creates data on the user's device (browser), without requiring an explicit user permission, an attacker may use the same procedure to access user's sensitive data, e.g., user's credentials. But since we are dealing with a hybrid application, which is encapsulated as native Java application, the risk of cross-site scripting via browser

is non-significant.

5.4.2 Performance

In general, the performance is one of the most challenging issues for each hybrid application. On the one hand, this is due to the permanent switch between the web and native components of the application, and on the other hand if DOM operations are not congruously used, they may easily turn into redoubtable performance issue.

DOM operations are JavaScript operations that interact directly with objects in HTML, XHTML and XML documents, and thereby modifying the content of the documents. Constant mixed reading and writing operations influence the JavaScript performance strongly, and the whole application. Hence, it is important to avoid or minimize such combined operations. In order to increase the performance in the of Bayasella application, we handle reading and writing operations separately. Mostly, we first read the DOM and then modify it once at the end.

5.5 Portability of the provided Approach

In the meantime we know that Bayam Sellam are commuter retailers and salesmen between urban and rural areas. Due to the poor quality of the transport means, planning the travels according to the weather forecast may additionally contribute to improve their activity. Furthermore, at the beginning of the supply chain, i.e., in the rural areas, the daily activities of the farmers mainly dependent on mastering weather conditions. Therefore, for planning agricultural and business activities, we may provide weather forecasting for mobile devices to the actors.

In fact, the main architectural building blocks and the technical approach, on which Bayasella relies, are applicable to other class of tailored applications for other groups of users. To showcase the portability, we suggest a m-weather forecast application that combines international weather forecast data with traditional weather data from indigenous population, such as the Tupuri (Tpuri) folk.

5.5.1 State of Weather Prediction in Cameroon

Weather forecast is of great importance especially for rural populations involved in agricultural activities. However, having access to accurate weather forecasts is not easy for the population in Cameroon. The "Cercle de Concertation de la Société civile

Partenaire du MINFOF/MINEP" [2] (Ministère des Forêts et de la Faune/Ministère de l'Environnement et de la Protection de la Nature) diagnosed the case of meteorological data in Cameroon. The report published in February 2012 [CCSPM 2013] stipulates that out of the 58 existing weather stations in Cameroon, only three operate. The deteriorated infrastructure is not the only challenge. The lack of technical personnel makes the situation worse. The same report declared that out of the 59 meteorologists in Cameroon in 2010, nine went on retirement during 2011, and 15 others will be retired between 2012 and 2015.

In Cameroon, the meteorological services are managed by the National Meteorological Service (NMS) of Cameroon, which is under the supervision of the Ministry of Transport. The tasks assigned to this service are, among others, the gathering of climate information, the composition of weather forecasts, the dissemination of meteorological information, and so forth. Except for the air transport, for which the weather data are unavoidable, no more data are available, for example, for planing the agricultural activities.

Indeed, many Cameroonians involved in farming activities face the challenge of accessing understandable weather data, because they mostly rely on non-quantified traditional weather knowledge and, if any, on some sporadic meteorological forecasts. Providing more accurate weather forecast requires the collection and analysis of a large amount of data. That means the data should be collected over the years in order to generate accurate weather forecasts for farmers.

In Cameroon, as in many Sub-Saharan countries, the insufficiency of weather forecasting services leads to extreme weather and climate events with often various consequences [Kignaman-Soro 2009], which include loss of lives and livelihoods, damage to infrastructure, increased risk of disease outbreaks, lack of food/water/pasture, mass migration, degradation of the environment, retardation of socio-economic growth, etc. For example, in August 2012, in the far north region of Cameroon, a sudden flood caused various disasters and victims. Crops were destroyed, cattle disappeared, citizens were forced to leave the flooding areas and some people perished under the massive inundations [Jeune Afrique 2013]. This disaster would have been prevented, hindered or limited, if a weather forecaster was available to dispatch information for warning the population living in the affected areas. Furthermore, if traditional weather knowledge was used systematically, the population would have been helped to predict and prevent, or at least limit any risk related to extreme weather conditions.

[2] Dialog Group of the Civil Society Partner of Ministry of Forestry and Wildlife, and Ministry of Environment and Protection of Nature.

5.5.2 Native Weather Forecast Techniques: Case of Tpuri

Tpuri is one of the around 250 ethnic groups established in Cameroon. They live in the northern part of Cameroon and southern part of Chad, and extend on both sides of the borders between the two countries. The latitude and longitude of the area where the Tpuri live (Tpuriland) in Cameroon, is 10° north and 15° east.

The majority of the population lives in rural areas and therefore have agriculture as their main activity to earn their living. In this region, the agricultural activity encompasses crops such as millet/sorghum, peanuts, onions, beans and rice. The farming of such crops is highly sensitive to climate changes (drought, flood, etc.), therefore, weather prediction is of high importance for those populations.

In order to predict the climate changes and give details on the weather conditions, the Tpuri folk rely on indigenous weather knowledge, which is oral and descriptive. In general, the terminology for weather and climate uses words such as dry, wind, rain, humidity, tornadoes, etc. Also, the Tpuri rely on such words to describe the weather and climate changes. In order to understand the way this folk describes the weather, we shall consider their calendar description. The Tpuri's calendar is seasonal, therefore, it is based on the local sequence of natural and agricultural events. Compared to the Gregorian calendar, for the Tpuri folk, the new year starts in October.

In Table 5.2, the first row indicates the months in Tpuri and the second in English. Thereby, *few* means month or moon. For example, *few burgi* means month of dust, indicating the period prior to the rains, during which it is dusty and windy.

few kage	*few duugi*	*few baare*	*few daa*	*few darge*	*few ka'arang*
October	November	December	January	February	March

few mene	*few burgi*	*few baa*	*few yaale*	*few jon fen sõore wa*	*few wang*
April	May	June	July	August	September

Table 5.2: Month Correspondence: Tpuri vs. English

Table 5.3 provides the meaning of each month, and some related seasonal activities. Furthermore, classified as an event calendar, the same table shows natural phenomena associated to each *few*, including meteorological events. Temperatures are described orally according to each *few* [Kolyang, 2010]. The Tpuri only describe the way they feel the weather, i.e. the sensation of the temperature but not the degrees. They do not use any unit to measure the temperature.

Few	***Explanation***	***Meteorological events***	***Reference***
ancoo	months of cold season, harvest season: peanuts, peas potatoes	cold	October to November
ceere	moon of cool	cold, very cold	December to January
hissi	period of high heat	dry, hot, sun	February to March
burgi	moon of dust	light to heavy wind, dust	April
jo'ge, kabge, mulum	months of sowing, begin of rainy season	light rain	May
baa, yaale	moon of rain / rainy season	rain, humidity	June to July
gumugi, musgware	people are weak and easily catch diseases / outbreak of diseases due to heavy rain	heavy rain, humidity	July to August
hoole gara	red millet harvested at the end of rainy season	rain, humidity	August to September
twale	months when the sun burns	light rain, sun, very hot and humid	September to October

Table 5.3: Tpuri calendar for activities
Adapted from ([Kolyang 2010], p. 40)

In Table 5.3, *ceere*, which means cold, is the period in which temperatures range between 15° and 20° C, and *hissi*, which means hot, is the period when temperatures start from 30° C. From September to October is the *hissi* period, which means humid and hot. Consequently, the table builds data records that use, for example, month or temperature as reference to match the traditional weather description with those from the existing weather systems. An API shall combine these indigenous knowledge with structured weather data from existing weather forecast systems.

5.5.3 Weather Forecast APIs

Various weather APIs are available online. Mostly, they use the Representational State Transfer (REST), which leverage the HTTP protocol to provide weather data in JSON or XML format to other related systems.

The World Weather Online (WWO) API provides, for a chosen area and also for the Tpuriland, current weather information, as well as for the next 15 days, and the past, up to the 1st July 2008. Some of the information available through this API is the

date/time of the observed weather conditions, the temperature, element description (such as precipitation, humidity, wind speed/direction, atmospheric pressure), weather description with text and images.

To retrieve information using WWO API, developers shall build HTTP requests, including specific keyword variables that refer to specific requested weather, location or data/time attributes. Such attributes are city (filtered by country), town name (filtered by country), latitude and longitude, or IP address. Furthermore, they shall specify the API key (which specifies the licence for its use), the format (XML, JSON or CSV) for the results, and the number of days for the forecast. The country is an optional value.

An example of an HTTP request, built upon the free WWO API, for the region of Kolara in Cameroon, where the Tpuri folk lives, looks as follows:

http://free.worldweatheronline.com/feed/weather.ashx?key=xxxxxxxxxxxxxxx&q=10.272019,14.650269&date=2013-02-14&format=json

The previous request provides the following average of rainfall and temperature for Kolara in 2012.

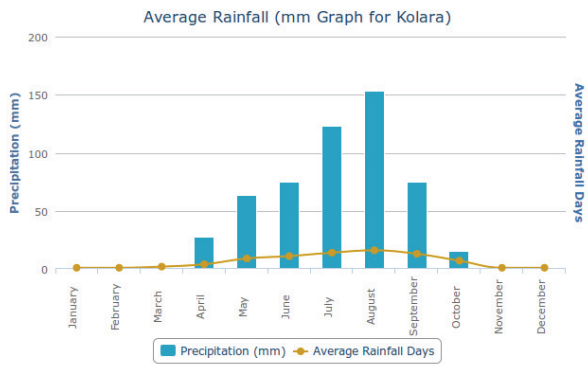


Figure 5.8: Average rainfall
Source: worldweatheronline

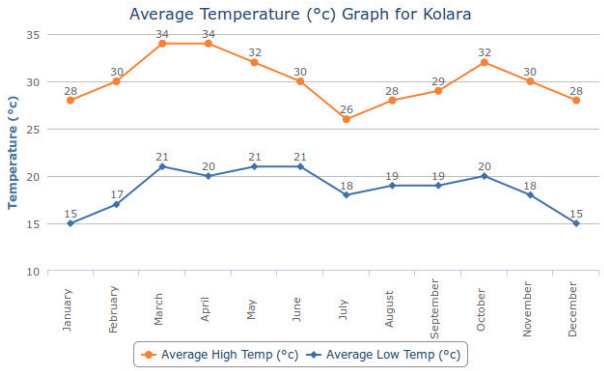


Figure 5.9: Average temperature
Source: worldweatheronline

For the same aforementioned query, the portion of the result in JSON format for the 14th February 2013, would look like in Listing 5.2.

```
{
   "data": {
      "current_condition": [
         {
            "cloudcover": "0",
            "humidity": "6",
            "observation_time": "12:19 PM",
            "precipMM": "0.0",
            "pressure": "1006",
            "temp_C": "38",
            "temp_F": "100",
            "visibility": "10",
            "weatherCode": "113",
            "weatherDesc": [
               {
                  "value": "Sunny"
               }
            ],

            "weatherIconUrl": [
               {
                  "value": "http://www.worldweatheronline.com/
                  images/wsymbols01_png_64/wsymbol_0001_sunny.png"
               }
            ],
            "winddir16Point": "NNE",
            "winddirDegree": "11",
            "windspeedKmph": "13",
            "windspeedMiles": "8"
         }
      ],

      "request": [
         {
            "query": "Kolara, Cameroon",
            "type": "City"
         }
      ],

      "weather": [
         {
            "date": "2013-02-14",
            "precipMM": "0.0",
            "tempMaxC": "39",
            "tempMaxF": "102",
            "tempMinC": "24",
            "tempMinF": "74",
            "weatherCode": "113",

     ....

            ]
     }
}
```


Listing 5.2: JSON Weather Data for Kolara on 14th February 2013

Based on the weather forecast provided by the free WWO API, we suggest an API model that combines those data with the traditional and indigenous climate knowledge that the Tpuri use, for local weather reference. The process of data integration

starts by requesting the weather description from the WWO, via the existing API, and matches them with the indigenous weather references, which are based on the aforementioned calendar.

The overall system architecture looks like follows:

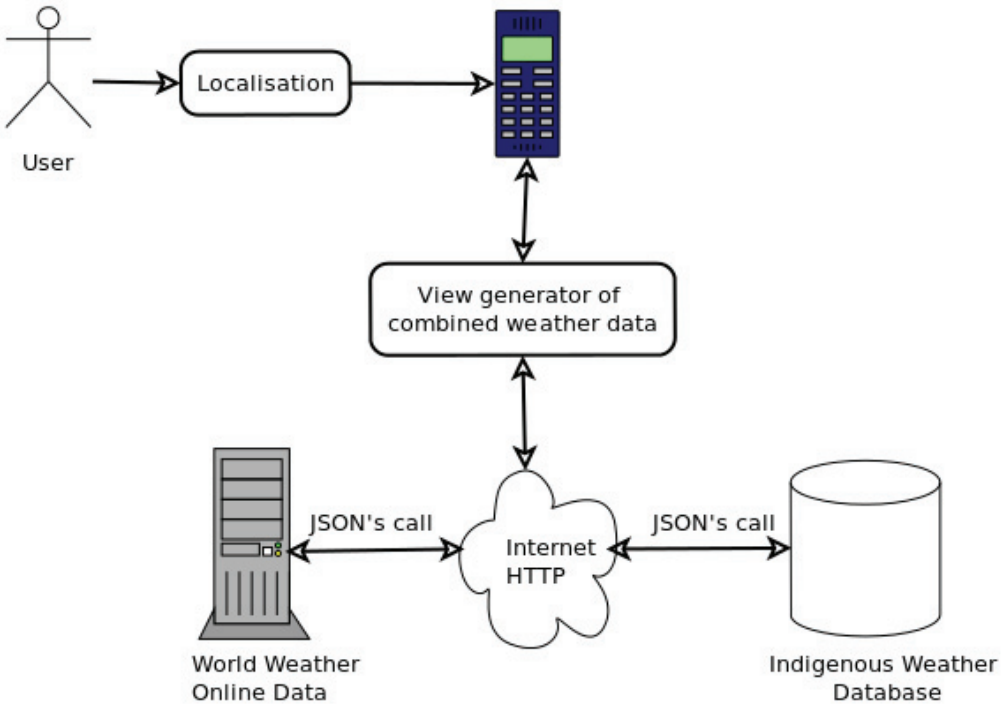


Figure 5.10: Integrated Weather API

As shown in Figure 5.10, the model consists of the following parts:

World Weather Online Data
This component contains WWO data, delivered via a previously subscribed free API, which provides access to current weather conditions and for the next five days. When an Internet connection is available, WWO data are retrieved upon demand. For a given area, the data are extracted in JSON format and saved locally on a mobile phone. Optionally, users may extract data for next five days.

Indigenous Weather Data (IWD)
Indeed, the m-weather can be embedded in the existing infrastructure. The MCTs constitute the appropriate infrastructure for hosting IWD. For instance, a relational database server (e.g., MySQL) may handle IWD analysis and storage by means of database services. IWD refer basically to descriptive terms that the Tpuri use to specify weather characteristics. Once m-weather users get connected to any MCT or go online, IWD are downloaded and locally stored (on the handheld device) using a Web

SQL database.

View Generator
This part is an API that matches the data provided by WWO, IWD and the user data, to generate new views. The view generator receives the JSON input from the aforementioned APIs and produces a combined JSON file. The weather forecast data include date details that are being matched with the month reference details in the descriptive data. This data combining is being performed offline.

Mobile Device
The mobile users contribute by recording current weather terms in own region and sending them to the IWD database through MCT over via a personal Internet connection. The mobile device presents the different views of combined data produced by the view generator. The view is location-dependent. The example of weather data for the locality of Kolara is generated by means of geolocation data, namely the GPS coordinates latitude (10.272019) and longitude (14.650269) respectively. The view generator extracts a JSON file with the combined weather forecast. This file then can be used by a mobile application to print the results in several formats, namely the views.

Comparing the architectural components of both applications and the data processing, i.e, m-commerce and m-weather, we assert that, in both cases:

- JSON component takes care of all synchronisation issues.
- Online Database handle the data exchange.
- Little Internet connection is needed, due to the ability of the application to operate mostly offline using Web SQL Database.
- Mobile users contribute with own knowledge to the content of the m-application.
- All is about the search and use of local information.

The reasons driving our choice for both architectures are similar. The technical ingredients suggested for the development of the m-commerce solution are applicable to the m-weather forecast solution.

Once the m-weather forecast app is loped and installed on the user's mobile device, a typical weather synchronisation process would look like this:

1. The user goes online, whenever the Internet connection is available.
2. Data are download from the WWO server in JSON format.
3. Indigenous data in JSON format are once downloaded from the IWD server and saved locally.

4. Transformed and combined, the data from WWO and IWD servers produce a new JSON output.

5. Diverse views (images, symbols, text, etc.) may be loaded and displayed on the mobile device.

Consequently, the implementation of the m-weather architecture will lead to a hybrid mobile application that relies on the similar architecture approach as it was previously the case for the m-commerce application. This again may be applied to further domains.

6 Implementation and Interfaces

In the previous chapter, we discussed two possible architectural options of Bayasella. The architecture based on Internet was classified as the most appropriate. We also demonstrated the applicability of the suggested solution to another domains. The current chapter starts with the presentation of the whole development environment including necessary tools and frameworks. Next, some portions of code examples illustrate the implementation paradigms.

The chapter also provides some screens of the user interface . It ends with test processes and results, including feedback gained from an in-situ test done in Ngaoundéré.

6.1 Tools and Languages

To implement the Bayasella app, a set of tools, frameworks, and programming languages was required. To set up a complete development environment, we used various technical ingredients, notably:

- **Apache 2.2.21**, a Web server for hosting and delivering the Web content such as the synchronisation scripts;
- **CSS3**, a style sheet language for describing the presentation semantics of the HTML portion;
- **Eclipse IDE**, a development environment for integrating various tools, frameworks and writing the app code.
- **HTML5**, a markup language, also known as a set of technologies that pertain to it for persisting Web app data locally;
- **JQuery library**, a JavaScript library for simplifying the client-side scripting;
- **mod_ssl 2.2.21**, a module of Secure Sockets Layer (SSL) used to support HTTPS communication;
- **MySQL 5.5.16**, a database server for creating and hosting the online interface database;
- **PhoneGap Cordova version 1.6.1**, a mobile development framework for accessing native device APIs;
- **PHP 5.3.8**, a script language for developing dynamic synchronisation scripts;
- **SDK Platform Android 4.2, API 17**, for building, testing, and debugging apps for Android platform;

- **Java Runtime Environment 1.7.0_25**, for packing the whole code as a native app.

6.1.1 Eclipse and Required Plugins

Known as a multi-language Integrated Development Environment (IDE), Eclipse (screenshot in Figure 6.1) is one of the main IDEs used in the Java development community. It supports manifold languages and tools by affording comprehensive advantages, for instance, through the integration of various tools via the plugin mechanism.

The implementation of Bayasella using Eclipse required three essential extensions or plugins: the SDK Platform Android, the PhoneGap Framework, and the Eclipse Web Tools Platform. In addition, we configure an emulator to facilitate app debugging and testing without using any physical device. We may also mention that the Eclipse Web Tools Platform aims to provide syntax highlighting, autocompleting features for various languages (Java, PHP, HTML, XML, JavaScript, etc.) we used during the implementation. All these constitute ingredients for setting up an appropriate development environment.

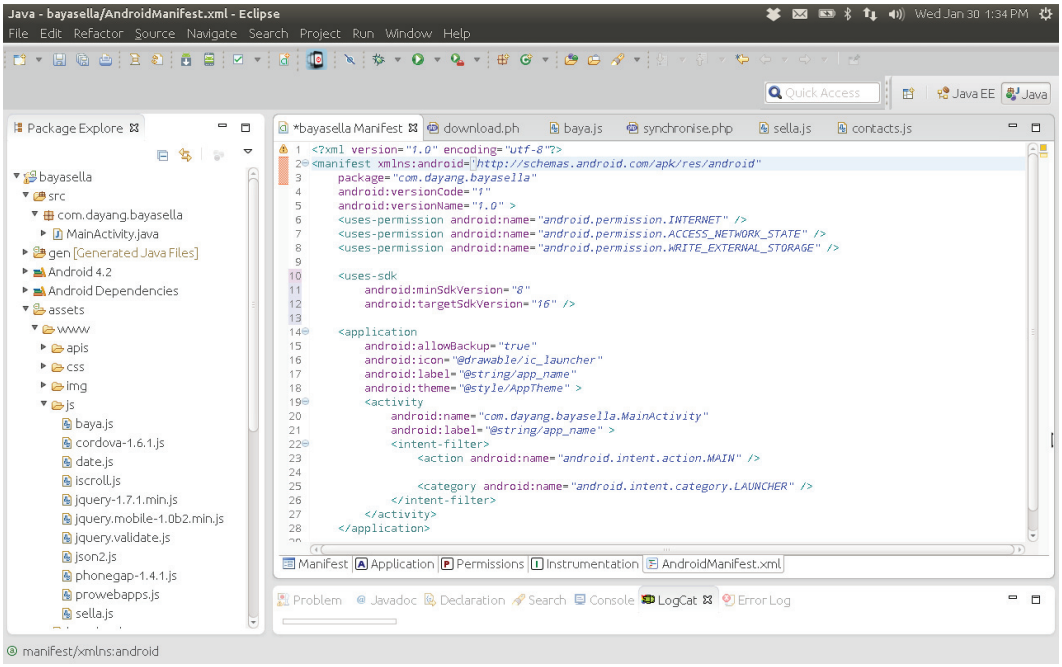


Figure 6.1: Eclipse IDE

6.1.2 PhoneGap as a Development Framework

There exist various frameworks that support the development of platform-independent applications, for instance, Titanium Mobile, The-M-Project, PhoneGap, etc. Each of

these frameworks is supposed to provide some standard libraries for network management, access to geolocation data, design patterns, etc. serving to alleviate the overhead associated with common tasks performed during development. The development time may thereby be minimised. To pick a concrete development framework, we relied on the following criteria:

- It shall support WebKit-based apps for Android.
- It shall be a classified as an open source framework.
- It shall support the access to multiple device APIs.

Furthermore, our choice was also directed by the mobile frameworks comparison chart done by Falk [2013] and the description of mobile features supported by PhoneGap [2013]. From this comparison, PhoneGap was qualified as the most appropriate tool.

In fact, PhoneGap is an open source framework that provides a simple and lightweight approach for wrapping a mobile web application to be deployed as native. PhoneGap comprises features that implement a full access to device APIs, as it is shown in Table 6.1.

Feature/Platform	**Native**	**Hybrid**	**HTML5**
Accelerometer	++	++	-
Camera	++	++	-
Compass	++	++	-
Contacts	++	++	-
File	++	++	-
Geolocation	++	++	++
Media	++	++	+
Network	++	++	-
Alert	++	++	-
Sound	++	++	-
Vibration	++	++	-
Storage	++	++	+

Table 6.1: Feature supported by PhoneGap
++ supported, + partly supported, - not supported

Figure 6.2 [Worklight, 2011] describes the interactions between the different components of a typical hybrid application. It shows the position of PhoneGap and presents diverse steps of data communication, for instance, input (audio through microphone), output (audio through speaker), or input-output data (through WiFi). Each access goes through the mobile operation system, by means of OS-specific APIs.

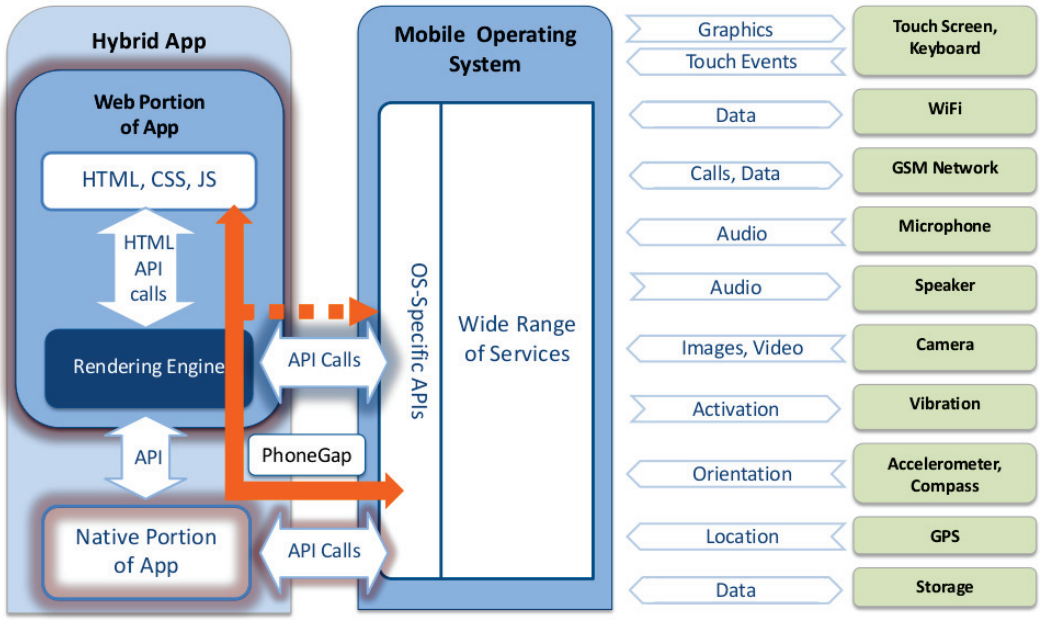


Figure 6.2: Hybrid architecture acc. to IBM Worklight (2011)
Source: IBM Worklight

6.1.3 Communication with Remote Database

According to the architecture based on Internet Network, we distinguish four cases in which Bayasella needs to communicate with the remote database via a HTTP communication protocol. These cases include:

1. When a seller wants to synchronise products, after offers have been stored locally.
2. When a buyer wants to enrich her/his wish list by downloading offers.
3. When a seller wants to view how often a product has been downloaded.
4. When a governmental department intends to generate a list of offers.

Requiring an Internet connectivity, all four remote communication cases are handled online by scripts hosted on the Apache Web Server. When a seller uploads offers, data are pushed online in the relational database, which provides an efficient, structured, and generic system for managing persistent data. During the synchronisation process, the combination of the default seller's phone number and the product ID is built and used as an identifier for each offer dataset in the online database. Broadly, Listing 6.1 and Listing 6.2 illustrate how the up/download process is technically implemented.

Getting Data ready for uploading: Offline execution

The uploading process is done in two essential steps, which are proper to each operation, necessitating distant data exchange. The two steps should ensure that actions incurring additional charges be done without ambiguity. In fact, the local part of the

synchronisation script (Listing 6.1) selects datasets from the Web SQL Database and converts them into jQuery objects, which are offers. Ultimately, the objects are customized and passed on to the HTTP protocol that executed the online part of the script, whose portion is presented in Listing 6.1.

```
// Process of uploading product into remote MySQL database
function synchroniseOneProduct(prod_id) {
 product = null;
 if (prod_id) {
  db.transaction(function(transaction) {
   transaction.executeSql(
    "SELECT rowid as id, * FROM product WHERE id="
      + prod_id, [], function(transaction,
      results) {
     product = results.rows.item(0);
     if (product) {
      $.post("http://.....bayasella/synchronise.php", product,
        function() {
        // Change the product status to synchronised
                          prod = new module.Product(product);
                          prod.synchronise();
                          BAYASELLA.Storage.saveProduct(prod, null);
                  $("#info")
              .html("<b>'" +product.name + "'</b> has successfully
                  been synchronised.")
                            .css("display","block");
         });
      }
     });
  });
 }
}
```

Listing 6.1: Getting Data ready for uploading offline

Getting Data ready for uploading: Online execution

The online part of the script (Listing 6.2) begins with the database connection via the corresponding credentials. The product characteristics are then extracted from the JQuery object data, that has previously been generated and received via HTTP protocol. For each attribute, possible white spaces either at the beginning or at the end are removed. In order to preserve the meanings of HTML entities, special characters are converted into HTML entities. Then, the refined data are processed by queries written in a high-level language, the SQL Language, to store the product data in the relational database persistently.

```
/* Converts some predefined characters to HTML entities after
   trimming them */
$name      = htmlspecialchars(trim($_POST['name']));
$description = htmlspecialchars(trim($_POST['description']));
$price       = htmlspecialchars(trim($_POST['price']));
$category    = htmlspecialchars(trim($_POST['category']));
$owner       = htmlspecialchars(trim($_POST['owner']));
```

```
$phone       = htmlspecialchars(trim($_POST['phone']));
$place  = htmlspecialchars(trim($_POST['place']));
$synchro_id  = htmlspecialchars(trim($_POST['id'])).
               htmlspecialchars(trim($_POST['phone']));

/* Building an expression containing values to be verified */
$prod_jquery = $name!="" && $price!="" && $owner!="" && $phone!="" &&
   $synchro_id!="";

// Updating existing offer or inserting a new one
if($prod_jquery){

  $sql_prod = "";

  // check product id for update
  $sql_checkproduct = "SELECT * FROM product WHERE
     synchro_id='".$synchro_id."'";
  $res_checkproduct = mysql_query($sql_checkproduct);

  if (mysql_num_rows($res_checkproduct)  == 1) {
    $sql_prod = "UPDATE product SET name='".$name."',
       description='".$description."', price='".$price ."',
       place='".$place."', category='".$category ."',
       owner='".$owner ."', phone='".$phone ."', created=NOW(),
       due=DATE_ADD(NOW(), INTERVAL 3 DAY) WHERE
       synchro_id='".$synchro_id."'";

  }else{

   $sql_prod = "INSERT INTO product (name, description, synchro_id,
      price, category, owner, phone, place, created, due) VALUES
      ('".$name."', '".$description."', '".$synchro_id ."',
      '".$price."', '".$category."', '".$owner."','".$phone."',
      '".$place."',NOW(), DATE_ADD(NOW(), INTERVAL 3 DAY))";
  }

  // persist data into MySQL exchange Database
  $result = mysql_query($sql_prod);

  if (!$result) {
    echo "Could not successfully run query ($sql_prod) for DB
       insertion: " . mysql_error();
    exit;
  }

}
```

Listing 6.2: Getting Data ready for uploading online

A successful synchronisation process changes the product status from *open* to *synchronised* locally, and a message is displayed to the user. In case the synchronisation process returns an error the user is likewise notified.

Getting Data ready for downloading

According to the product category (fruits, vegetables, poultry, etc.) chosen by a potential buyer, a set of queries retrieve the matched products. The offer datasets are then processed in a PHP code and converted into JSON format. Until now, everything is done online (Listing 6.3). Finally, the products are stored locally in Web SQL database

(Listing 6.4).

```
/* List of categories selected by the buyer */
$categories_tmp = $_REQUEST['cat'];
if($categories_tmp!="") {

  // create a set of categories for SQL IN condition for avoiding
     multiple SQL "OR" conditions
 $categories = str_replace(',', "','", $categories_tmp);

 /* get products from the database */
 $query = "SELECT * FROM product WHERE category in
    ('".$categories."') AND NOW() <= due";
 $result = mysql_query($query) or die('Errors in query :'.$query);

 /* create one master array of the records */
 $products = array();
 if(mysql_num_rows($result)) {
  while($product = mysql_fetch_assoc($result)) {
   $products[] = array('post'=>$product);
  }
 }

 /* Output in JSON format, to be used later for local storage */
 header('Content-type: application/json');
 echo json_encode(array('posts'=>$products));
}
```

Listing 6.3: Getting Data ready for downloading

Getting downloaded Data ready for inserting into Web SQL Database

The downloading script (Listing 6.4) receives offer data in JSON format, and they are ready to be stored locally, as persistent data. After a successful storage, a message is displayed to the buyer, indicating the number offers or products downloaded.

```
// persist downloaded offers locally
saveProductToBuy: function(categories, callback) {
 // get offers from distant server
    $.post("http://.../bayasella/download.php?cat="+categories,
       categories,
 function(data) {
  // loop data
  $.each(data.posts, function(i,post){
   $.each(post, function(j,product){
          db.transaction(function(transaction) {
                    transaction.executeSql(
                        "SELECT prod_id FROM product WHERE
                           bs_status='to_buy' AND
                           prod_id="+product.prod_id,
                        [],
                        function (transaction, results) {
                            // Check if such an offer exists locally.
                            if(results.rows.length > 0){
                            // update existing offers locally
        "UPDATE product SET name = ?, description = ?, price = ?,
           owner = ?, place = ?, due = ?, created = ? WHERE rowid =
           ?;",
```

```
          [product.name, product.description, product.price,
             product.owner, product.place, product.due,
             product.created, product.id],
                            }else{
                            // insert new offers locally
                          transaction.executeSql(
                             "INSERT INTO product(prod_id, name,
                                description, price, category, owner,
                                place, phone, bs_status, created)
                                VALUES (?, ?, ?, ?, ?, ?, ?, ?, ?,
                                ?);",
                             [product.prod_id, product.name,
                                product.description, product.price,
                                product.category, product.owner,
                                product.place, product.phone,
                                'to_buy', product.created],
                             function (tx, res) {}
                          );
                             }
                       }
                    );
                 });
          });
          /* Message to be displayed to the buyer after the
             downloading process.*/
    $("#info")
      .html(data.posts.length +" Products have been downloaded! Go to
         'buyable products' to see the list.").css("display","block");
  });
 });
},
```

Listing 6.4: Getting downloaded Data ready for local storage

Before up/downloading offers, the user may check the connection status explicitly. As the corresponding function is shown in Listing 6.5, seven connection types are possible.

```
function getConnectionType(type) {
 var connectionTypes = {};
 connectionTypes[Connection.NONE] = {
  message: 'Offline',
  value: 0
 };
 connectionTypes[Connection.UNKNOWN] = {
  message: 'Unknown connection',
  value: 1
 };
 connectionTypes[Connection.ETHERNET] = {
  message: 'Online: Ethernet',
  value: 2
 };
 connectionTypes[Connection.CELL_2G] = {
  message: 'Online: Cell 2G',
  value: 3
 };
 connectionTypes[Connection.CELL_3G] = {
  message: 'Online: Cell 3G',
  value:  4
 };
 connectionTypes[Connection.CELL_4G] = {
```

```
  message: 'Online: Cell 4G',
  value: 5
 };
 connectionTypes[Connection.WIFI] = {
  message: 'Online: WiFi',
  value: 6
 };

 return connectionTypes[type];
}
```

Listing 6.5: Connection code

6.2 Code Examples of DOM or local Storage

As described in the previous chapter, we rely on HTML5 technology, in particular the DOM storage mechanism, to implement Bayasella. Some code examples are now provided describing how to apply the storage mechanism in a programme code.

Known as a JavaScript object, **localStorage** acts as an associative array. Instead of using *getItem()* and *setItem()* methods, we can also use square brackets (*[ ]*) for the named key/value pairs.

Example 1: Storing seller's data
In Listing 6.6, we collect the name and phone number from two form fields, which are *productowner* and *productphone*, and they are finally saved in two variables *myName* and *myPhone* respectively.

```
localStorage.setItem("myName", $('#productowner').val());
localStorage.setItem("myPhone", $('#productphone').val());
```

Listing 6.6: Storing seller's data

Example 2: Retrieving seller's data
Listing 6.7 shows how name and phone number can be retrieved from the variables *myName* and *myPhone* to which values have been previously assigned. Finally, the values are then assigned to two fields in a form, productowner and productphone notably.

```
$('form #productowner').val(localStorage.getItem("myName"));
$('form #productphone').val(localStorage.getItem("myPhone"));
```

Listing 6.7: Retrieving seller's data

Example 3: Removing seller's data (name and phone number)
Listing 6.8 removes the values of the variables *myName* and *myPhone*. One could also say the variables are emptied.

```
localStorage.removeItem("myName");
localStorage.removeItem("myPhone");
```

Listing 6.8: Removing seller's data

Example 4: Storing an object
Furthermore, we can store objects with the values of their properties and subsequently retrieve them. Listing 6.9 shows how an object *fruit* can be stored with two attributes and their values.

```
localStorage.setItem("fruit", {
 name: "Orange",
 price: "50 FCFA"
});
```

Listing 6.9: Storing an object

Example 5: Retrieving an object
Listing 6.10 shows how the object *fruit* can be retrieved, as a whole, from the local database.

```
var fruits = localStorage.getItem("fruit");
```

Listing 6.10: Retrieving an object

Example 6: Retrieving object properties
With Listing 6.11, we get the value of the attribute *name* of the object *fruit*, which is stored in the variable *fruits* declared in the previous code (Listing 6.10).

```
 var fruit_name = fruits.getItem("name");
```

Listing 6.11: Retrieving object properties

6.3 User Interfaces

The user interface is the way of displaying information produced by the application, and the way in which users can access application functionalities (Sommerville, 2011). So, everything the users can see and interact with belongs to the user interface. To highlight the user interfaces, some screenshots of the Bayasella prototype are illustrated.

6.3.1 Start Screen

Figure 6.3 shows the start screen of the Bayasella application, after it has been launched. Depending on the user status, she/he can choose to interact as a seller (I am a sella) or as a buyer (I am a baya).

If the user decides to interact as a *sella*, the last offer entered locally is displayed - if there is any - or an empty list is shown (Figure 6.4) and the seller can then enter new offers using the product entry form (Figure 6.12). On the contrary, if the user interacts as a potential buyer, the interface (Figure 6.11) for configuring the product downloading process is presented.

Figure 6.3: Start screen of Bayasela

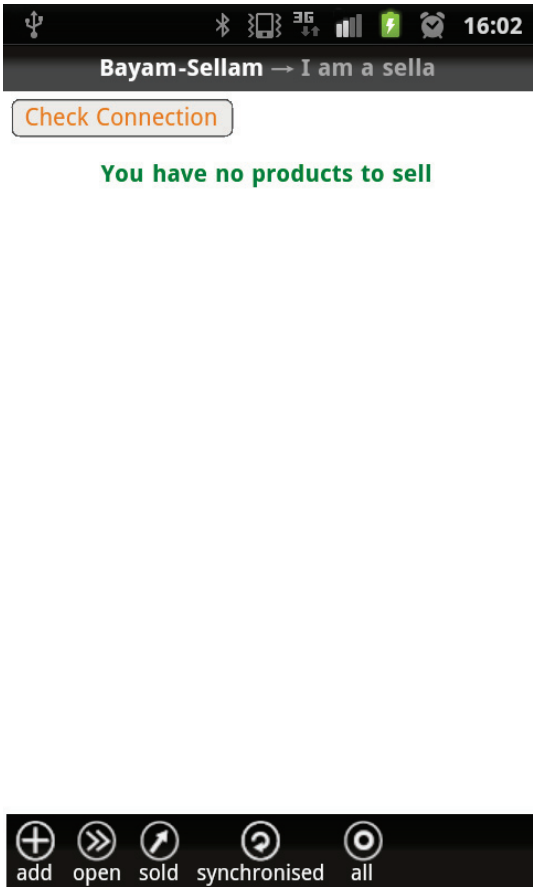


Figure 6.4: Bayasella without offers

The link "**What is Bayasella?**" leads to the app description and help for user orientation.

6.3.2 Setting Market Places and Resellers

A product offerer may define various market places or places of interest where products are available for sale, and many resellers to be stored in the database as well. Figure 6.5 shows the list of some market places and points of interest in Ngaoundéré and a list of resellers. At the end of each list, the product offerer is prompted to enter new values. The input fields are highlighted by the corresponding labels, i.e., *New market place*, *New reseller* and *Phone*. Finally, market places and places of interest can be withdrawn whenever needed and the resellers as well.

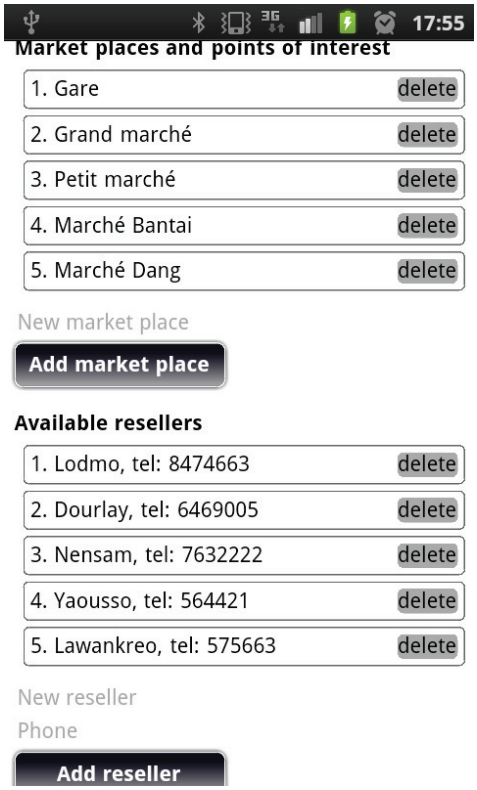


Figure 6.5: Setting market places and sellers

6.3.3 Offer Entry Form

By filling out the offer entry form, the last selected reseller and market place are always stored by means of local storage so that the next time, whenever another offer is being entered, these data are automatically pre-selected or pre-checked. In fact, when the offerer hits the save button, the data are locally save in two groups: all data related to online offers are stored in the Web SQL Database for a later synchronisation, and the data of reseller and market place in local storage.

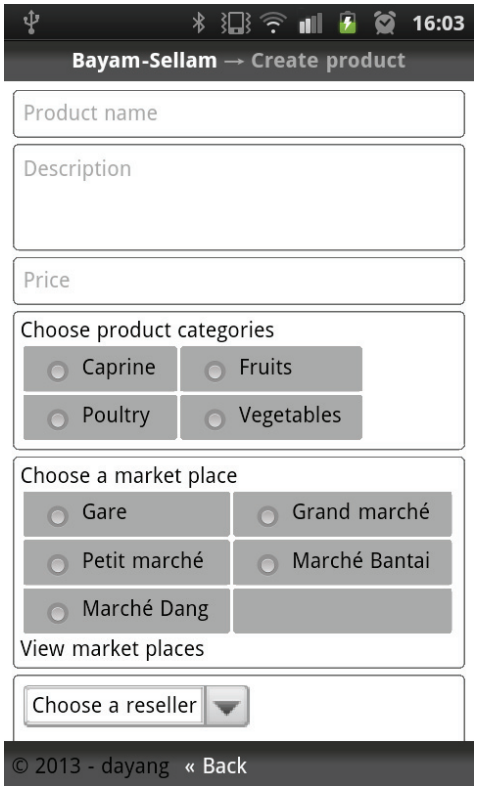


Figure 6.6: Form for entries

6.3.4 Offer List and Details

An offer registered successfully leads to Figure 6.7. As we mentioned in the previous chapter, we rely on the *Vertical List* and *Fisheye List* pattern for presenting the list of offers and the related details respectively (Figure 6.8). Clicking on an offer title slides the entire offer down and the offer details are displayed. In addition to the offer details, there is a contextual action menu comprising four items: *Synchronise* for setting offers online; *View downloads* for viewing how often an offer has been downloaded; *Sell* to mark an offer as sold and *Delete* for removing. The execution of each menu item slides the corresponding offer up and down, thereby recording the desired changes.

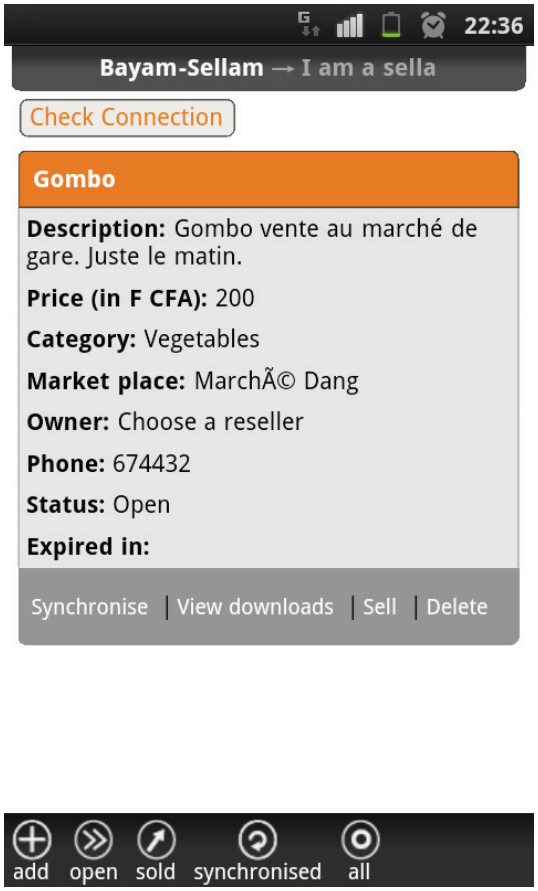


Figure 6.7: Offer details for sella

Figure 6.8: Offer list for sella

6.3.5 Synchronising and Downloading Dialogues

In general, the action either for synchronising or for viewing downloads are done in two steps, allowing the seller to interrupt the process if this is needed. As an example, the first click on the menu item *View downloads* leads to a dialogue box that contains a warning message as shown in Figure 6.9. Similarly, if a seller tries to resynchronise a product that has already been synchronised, a warning message is displayed (Figure 6.10). Next, the second dialogue box appears when the process has been confirmed. As supplementary details, each action aiming to view product downloads first verify the status in order to know if we are dealing with a properly synchronised product.

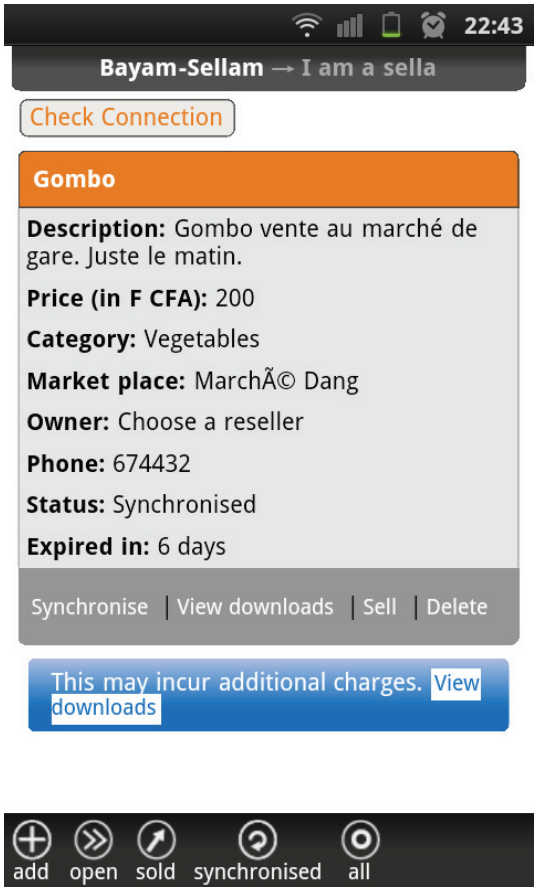


Figure 6.9: Downloading product view

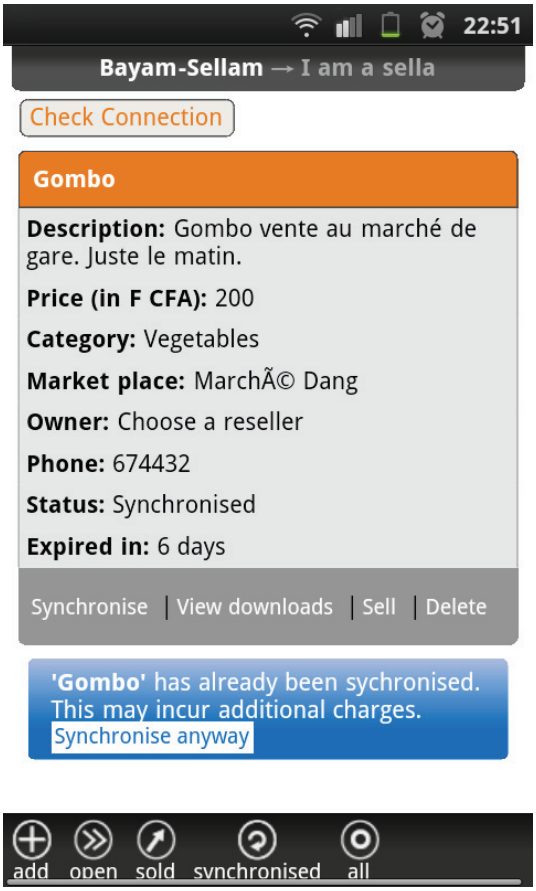


Figure 6.10: Resynchronising a product

6.3.6 Downloading Form and View of Downloaded Products

Categories, market places and time frames are provided as search criteria to the potential buyers who can configure the downloading process and thereby building the request to be sent to the remote database. The Web server hosting the online download script tracks downloads and saves them back by updating the attribute *download counter* of the downloaded offer. If the downloading process is successful, a message indicating the number of the downloaded offers is displayed. In case of troubles, provoked, for instance by the lack of Internet connection, the potential buyer is also notified.

Figure 6.11: Form for offer download

Figure 6.12: Form for offer entry

6.4 Testing

To verify if Bayasella meets the requirements that guided its design and development, we need to test it. We rely, for instance, on the statement of Myers [1979] who said: "Testing is the process of executing a program with the intent of finding an error".

In fact, we focus on two important steps. The first step is based on the tools used by implementers to debug and find errors during the process of Bayasella implementation. The second step is focussed on the feedback results collected from the potential users during the test of the first prototype.

6.4.1 Testing Tools for Developers

During the implementation process we relied on tools, for example, emulator, browser, etc. to uncover possible errors hidden in the written code. An emulator is a virtual Android device (AVD) that looks and acts just similar to a real Android device. It is necessary for developers to start getting the look and feel of the application at an early stage of the process. Immediately, after setting up Bayasella as a phonegap project in

Eclipse, an emulator was launched to reveal whether the combination Web and native components is error free, even though it contains no meaningful content.

First, the AVD is integrated in Eclipse via a plugin. Then, an emulator is created by setting the parameters such as AVD Name, Device, Target, CPU/ABI, Memory options etc. Figure 6.13 gives more details. Alternatively, the command line can also be used to set up the AVD.

The emulator is almost similar to real device (Figure 6.14).

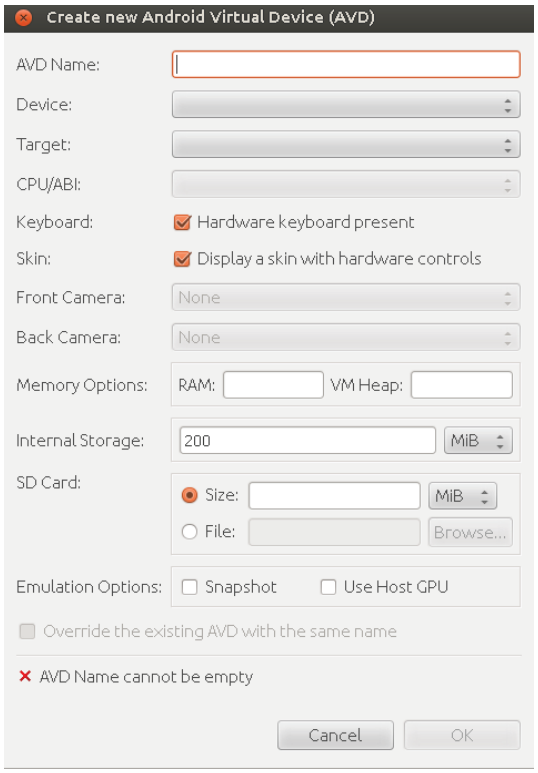


Figure 6.13: Setting up an AVD

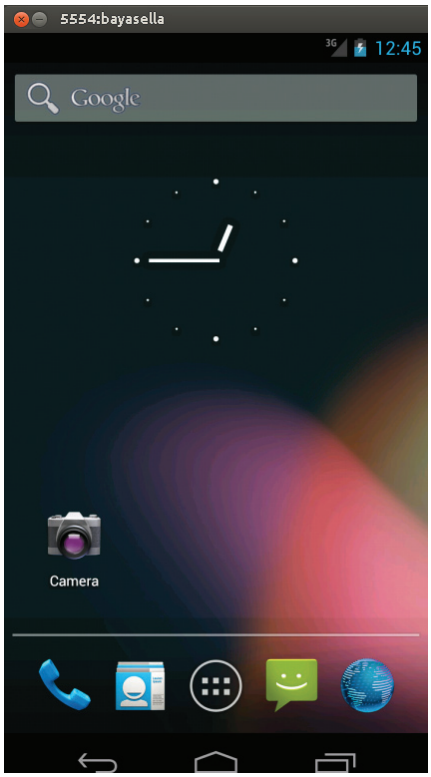


Figure 6.14: AVD 4.1.2 API Level 16

On-device test

Furthermore, an on-device test is undeniable for developers.

Browser test using Google chrome

The Google Chrome is an important and useful test tool specially for developers. Google Chrome uses a JavaScript-Engine based on the WebKit-Engine, which is also integrated in mobile platforms like Android and iOS. The browser plugin called **Developer Tools** (DT) provides appropriate tools for checking technical issues and examining the Web portions of the app, in particular at the level of code verification. The verification is performed without going through the whole compilation process, as it is the case for native applications. In terms of time, this is very gainful. In general, the plugin encompasses the following features that may be used for testing the behaviour of the Web portions of the hybrid application:

- DOM inpector,
- CSS-Live-Viewer,
- Network timeline,
- JavaScript console,
- WebStorage,
- WebSQL databases,
- Application Cache,
- In-Code-Editing and
- JavaScript debugger.

From the list above, we selected aim-oriented functions to conduct a browser-based check of diverse code and element constituting Bayasella. When needed, these features are also used for debugging during the implementation work. Table 6.2 gives precisely the list of the selected features and the corresponding code or element to be verified.

Feature of DT	**Code of element to be verified**
Elements	DOM elements, CSS file
Resources	local Web storage, Web SQL databases, loaded resources
Network	synchronisation scripts called over the network
Scripts	scripts as part of a loaded page, breackpoints in JQuery files, script runtime
Timeline	timeline of each resources, in particular the JQuery resources
Profiles	execution time of Bayasella, resources consumption
Console	JavaScript files, analysis of HTML elements

Table 6.2: Code testing

As a showcase, the selected panel *Resources* in Figure 6.15 shows our Web SQL database called *bayasella*. It shows the table *product* and two data rows. This features allows the developer to get an insight into the database structure and the persistent data that pertain to it. Likewise, data stored by means of the local storage can be inspected via this panel, by pulling down the menu *Local Storage*.

6.4.2 Testing by potential Users in Ngaoundéré

To effectively measure the look and feel of each software, testing on real end devices is necessary. For Bayasella, we conducted an on-device test using *Android 2.3.6*. The first

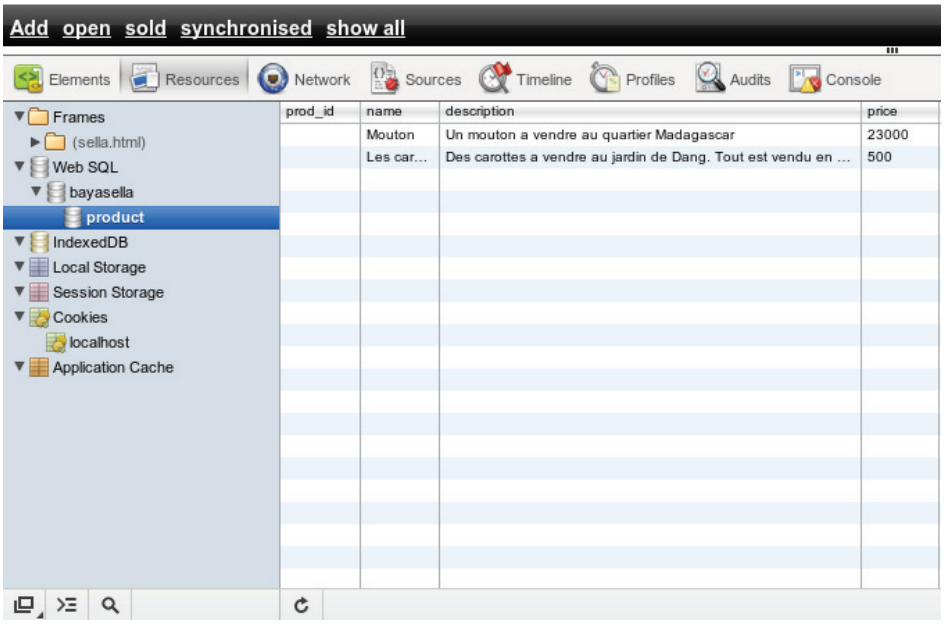


Figure 6.15: Browser test using Google Chrome

prototype was tested in 2012 in Ngaoundéré. This test aimed to gain and collect first impressions from the potential sellers and buyers using the app. At this early phase of the implementation, diverse desired changes and existing weaknesses were expressed by eight users (four women and four men). These users came out with the following main points:

1. Setting diverse market places or places of interest, where a seller can offer the same products, without keying them several times
Resulting requirement: Seller shall define a list of market places or places of interest.
Status: Requirement additionally implemented.

2. Organising sales at different places with different (re)sellers
Resulting requirement: Seller shall define a list of different (re)sellers.
Status: Requirement additionally implemented.

3. Checking if/whether/when offers have been downloaded
Resulting requirement: Seller shall view offer downloads.
Status: Requirement additionally implemented.

After considering and implementing the aforementioned requirements, a full structured test was conducted with five users. We relied on five users according to the statement of Nielsen (2012) on usability testing, arguing that if two or three people are totally confused with certain features, so there is enough reason to consider those features as weak and therefore improve them. The test cases are written according to the following attributes:

- **Test case name**: A unique key, indicating the name of the test case.

- **Description**: This is the explanation of the function to be tested.
- **Prerequisites and Input data**: It contains conditions and actions, which lead to the function under test.
- **Expected results**: This clearly states what is the expected outcome.

Test case name	Description	Prerequisites and Input data	Expected results
Seller_enter_offer	Verify that the seller can store offers.	Bayasella shall have at least one market place and reseller. Input data are: product name, price and description.	On clicking the *Save* button, Bayasella shall display the last stored product.
Seller_wrong_data	Verify that errors and hints can be displayed to the seller while entering unexpected data.	Bayasella shall have at least one market place and reseller. Input data are: product name, empty product description, price contains an alphanumeric value (e.g., 500CFA).	On clicking the *Save* button, Bayasella shall indicate that the product description is a mandatory field and the price field can only accept numeric data, for instance, 500 for a product that costs 500 F CFA.
Seller_enter_reseller	Verify that the seller can set up diverse resellers.	Input data are: seller name and phone number.	On clicking the *Add reseller* button, Bayasella shall display the resellers list.
Seller_enter_market	Verify that a seller can set up diverse market places and places of interest.	Input data is: name of the market place.	On clicking the *Add market place* button, Bayasella shall display the list of market places and places of interest.
Seller_sort_open	Verify that the seller can select only open products.	Bayasella shall have products with at least two different status, and among which at least one open	On clicking the *open* menu icon, Bayasella shall display the list of open products only.
Seller_sort_synch.	Verify that the seller can sort only synchronised products.	Bayasella shall have products with at least two different status, among which at least one synchronised.	On clicking the *synchronised* menu icon, Bayasella shall display the list of synchronised products only.
Seller_sort_sold	Verify that the seller can list only sold products.	Bayasella shall have products with at least two different status, among which at least one sold.	On clicking the *sold* menu icon, Bayasella shall display the list of sold products only.

Test case name	Description	Prerequisites and input data	Expected results
Seller_list_all	Verify that the seller can list all possible products.	Bayasella shall have products with different status.	On clicking the *all* menu icon, Bayasella shall display the list of all stored products.
Seller_delete_offer	Verify that the seller can delete products.	Bayasella shall contain at least one product	On clicking the contextual *delete* menu link, Bayasella shall display the product list without the withdrawn product.
Seller_mark_as_sold	Verify that the seller can mark products as sold.	Bayasella shall contain at least one product	On clicking the contextual *sell* menu link, Bayasella shall display the product marked as sold.
Buyer_mark_as_bought	Verify that the buyer can mark products as bought.	Bayasella shall contain at least one open product	On clicking the contextual *buy* menu link, Bayasella shall display the product marked as bought.
Buyer_delete_offer	Verify that the buyer can delete downloaded products.	Bayasella shall contain at least one product	On clicking the contextual *delete* link, Bayasella shall display the product list without the withdrawn product.
Buyer_sort_sold	Check that the buyer can display only the wish list.	Bayasella shall have products with at least two different status, among which at least one open.	On clicking the *wish list* menu icon, Bayasella shall display the list of open products only.
Buyer_sort_bought	Verify that the buyer can list only bought products.	Bayasella shall have products with at least two different status, among which at least one bought.	On clicking the *bought* menu icon, bayasella shall display the list of bought products only.
Buyer_list_all	Verify that the buyer can list all products.	Bayasella shall have diverse products with different status.	On clicking the *all* menu icon, Bayasella shall display the list of possible products.

Table 6.3: Test cases for Bayasella in offline mode

The results of the offline test cases are presented in Table 6.6. The column *Status* indicates how many users passed or failed the test, while the columns *Satisf. (Satisfaction)* and *Comments* give to which extent the users are satisfied and some useful comments respectively.

Test case name	**Status**	**Satisf.**	**Comments**
Seller_enter_offer	passed	100%	
Seller_wrong_data	passed	100%	
Seller_enter_reseller	passed	80%	Desirable: entry fields at the beginning of the list.
Seller_enter_market	passed	80%	Desirable: entry field far at the beginning of the list.
Seller_sort_open	passed	100%	
Seller_sort_synch.	passed	100%	
Seller_sort_sold	passed	100%	
Seller_list_all	passed	100%	
Seller_delete_offer	passed	60%	Desirable: deleting multiple offers at once.
Seller_mark_as_sold	passed	100%	
Buyer_mark_as_bought	passed	100%	
Buyer_delete_offer	passed	100%	
Buyer_sort_sold	passed	100%	
Buyer_sort_bought	passed	60%	Not necessary
Buyer_list_all	passed	100%	

Table 6.4: Results for offline test cases

Test case name	Description	Prerequisites and input data	Expected results
Seller_synchronise	Verify that the seller can synchronise products with the remote database.	Bayasella shall contain at least one product.	Next, click the contextual *synchronise* menu link: Bayasella shall display the message indicating that this action may incur additional charges. Then, the seller shall click on a second contextual *synchronise* link to confirm and complete the synchronisation process. Finally, Bayasella shall display the synchronised product with the new status *synchronised*.
Seller_view_download	Verify that the seller can view how often a given product has been downloaded.	The remote database shall have the product to be viewed, which has been downloaded at the least once.	Click the contextual *view downloads* menu link: Bayasella shall display the message indicating that this action may incur additional charges. Then, the seller shall click on a second contextual *view downloads* link to confirm and complete the process. Finally, Bayasella shall display the number indicating how often the chosen product has been downloaded.
Buyer_download_today	Verify that the seller can download products synchronised on the same day.	Bayasella shall have at least one product synchronised on the same day.	After configuring the download form by selecting categories, market places and *Today* as time during which the requested products have been synchronised, Bayasella shall display the number of downloaded products.

Test case name	Description	Prerequisites and input data	Expected results
Buyer_download_1day	Verify that the seller can download products synchronised one day ago.	Bayasella shall have at least one product synchronised one day ago.	After configuring the download form by selecting categories, market places and *Yesterday* as time during which the requested products have been synchronised, Bayasella shall display the number of downloaded products.
Buyer_download_4days	Verify that the seller can download products synchronised four days ago.	Bayasella shall have at least one product synchronised four days ago.	After configuring the download form by selecting categories, market places and *Four days* as time during which the requested products have been synchronised, Bayasella shall display the number of downloaded products.
Buyer_download_7days	Verify that the seller can download products synchronised seven days ago.	Bayasella shall have at least one product synchronised seven days ago.	After configuring the download form by selecting categories, market places and *One week* as time during which the requested products have been synchronised, Bayasella shall display the number of downloaded products.

Table 6.5: Test cases for Bayasella in online mode

Similar to the results of the offline test cases previously presented, below we summarise the results of the offline test cases in Table 6.6.

Test case name	Status	Satisf.	Comments
Seller_synchronise	4 passed and 1 failed	80%	Instability of Internet connectivity.
Seller_view_download	passed	80%	Costly feature.
Buyer_download_today	passed	80%	Display products directly after processing.
Buyer_download_1day	passed	80%	Display products directly after processing.
Buyer_download_4days	passed	80%	Display products directly after processing.
Buyer_download_7days	passed	80%	Display products directly after processing.

Table 6.6: Results for online test cases

At the end of this second testing phase, we should note that the online features of Bayasella are the most challenging. We summarise the essential arising weaknesses uncovered or improvements expressed by the users here below.

1. Checking the Internet connection
Resulting requirement: User shall Check the type of Internet connection via the Bayasella interface.
Status: Requirement additionally implemented.

2. Landing directly to the page listing the downloaded products, instead of displaying just the item's number
Resulting requirement: Bayasella shall display the list of downloaded items at the end of the downloading process.
Status: Improved. A link was included in the message indicating the number of downloaded items is shown separately.

3. Sharing products among sellers without incurring further charges
Resulting requirement: Sharing offers through an interface that does not require any payment, for instance, a bluetooth connection.
Status: Requirement is not implemented. Actually, the PhoneGap API does not support the bluetooth connection now for exchanging data from the interface of an hybrid application, in such a way to be directly integrated in another application.

4. Porting the whole application to a new phone, including the content defined by the user
Resulting requirement: The user shall important entire data to another mobile phone.
Status: Requirement is not implemented. Again, a possible cost effective solution is via a bluetooth connection, referring to the previous requirement.

Considering the user involvement during the entire development process, we may conclude that Bayasella is well appreciated but there is still enough room for improvement and refinement in regard to the remaining user's desires.

7 Conclusion and Future Work

The quintessence of this work was to provide technical approaches that aim to enhance the use of the existing mobile infrastructure in Cameroon. We have particularly focussed on a specific group of mobile users, called Bayam Sellam, living in the region of Adamawa (Ngaoundéré), by conducting a survey via a questionnaire whose results helped to collect data and interpret them. Known as commutator retailers between rural, suburb, and urban areas, Bayam Sellam try to harness the mobile technology. For this purpose we have provided a prototypical mobile commerce solution called Bayasella. It enabled ordinary users to suggest products for sale, to find products for purchase, to generate data on commercial activities for the governmental needs.

This work has shown that enhancing the use of the existing mobile infrastructure is subject to constraining factors such as lack of skilled personnel, intermittent Internet connectivity, low bandwidth, or electricity outages, etc. These constraints remain an overriding preoccupation in the Sub-Saharan region, which is predominated by countries with low income.

The provided m-commerce solution is adapted to the local needs, considering related technical constraints. After reviewing some main principles of m-commerce, this work has demonstrated that the suggested architecture is widely applicable to other groups of users, incurring less porting efforts. Thereby, we try to improve the way the folk Tpuri orally describe the weather forecast with the existing quantifiable way, used by well established weather forecasting systems, such as World Weather Online.

Indeed, the test of the Bayasella app done by five users revealed that there is still room for refinement and improvement of the suggested solution. From this experience, we may draw some notices while scrutinising the use of the existing mobile infrastructure as follow:

User satisfaction and acceptance of mobile technology
To be effective and due the ubiquitous characteristic of the mobile technology, continuous improvements are required in order to satisfy the mobile users and to make them accept and identify themselves with their devices and the offered mobile services.

Actually, the user satisfaction with mobile services often depends on two important factors that determine the usage of the mobile technology: mobile technology *diffusion* and *infusion*. Mobile technology diffusion measures how widely mobile technology is spread throughout an area, offering accessible and timely services. In Cameroon, the mobile network covers up to 80% of the country, therefore the mobile diffusion is more or less a secure deal. On the other hand, mobile technology infusion measures the extent to which mobile technology is deeply integrated into an area. If we again consider the Cameroonian context, this factor is still challenging and requires technology acceptance by the consumers. This factor could be satisfied if the provided services are more and more adapted to local needs and efficient in regard to the existing infrastructure. This

also assumes to acknowledge the need of appropriate services that integrate indigenous knowledge.

Extension of the m-commerce solution to Sub-Saharan Countries
Although, the Sub-Saharan countries have a wide variety of people, cultures, languages, economies and nuances; we refer to them as a whole for some reasons. Many of them have a shared colonial and post-colonial history [Mugoya 2011] and the development and usage of ICT in these countries have shown multiple similarities. Therefore, we might conclude that technological solutions for improving the use of mobile technology, such as the suggested Bayasella, can be extended to diverse Sub-Saharan countries.

In a nutshell, in the course of the analysis of ICTs usage and development conducted for ten Sub-Saharan countries, progress has been observed. But a lot of challenges, connected with difficulty and victory, remain as a call to specialists and other professionals of the mobile technology. Specially, the case of mobile penetration in Cameroon demonstrates that constraints are to be considered.

Future Work
Some questions could be asked and research topics formulated as follows:

- Africa has a rich oral culture, including myths, legends, folk songs, folk tales, proverbs and dance, which particularly serve as pedagogical practices. Meantime there are varying and conflicting interpretations of the digitalisation process in Africa. Therefore we may ask ourselves if the new forms of learning and teaching via ubiquitous devices are disruptive to the aforementioned traditional practices? Can the digitalisation process of tradition coexist with traditional practices?
- Can IT skills be improved in rural areas, where the literacy rate is low, educational initiatives are restrained due to financial shortages?
- How can the mobile penetration effectively be used to build robust education and skills development systems that will improve employability skills?
- How to circumscribe and subsequently integrate possible existing models that work elsewhere in the Cameroonian context?
- Cameroon has initiated the creation of multiple MTCs in various rural areas. How can we rely on such structures to spread the use of wireless technology?

Terms and Acronyms

2G, 3G, 4G: Respectively generation of cellular mobile communications standards.

Android: A Linux-based operating system for mobile devices.

API: Application Programming Interface.

ASBY: Association des Bayam-Selam du Cameroun.

AVD: Android Virtual Device.

Bayam Sellam: designs a profitable informal economic activity for the underprivileged class of Cameroonian, women and youths in particular. It consists of buying foodstuffs, which are mainly perishable goods, from rural areas and suburbs and reselling them in nearby or distant urban centers. A person who undertakes such an activity is also called *Bayam Sellam*. This is a typical word from the Cameroonian pidgin language which is classified in the category of lingua franca..

CAB: Central African Backbone.

CAGR: Compound Annual Growth Rate.

CAMTEL: Cameroon Telecommunications.

CPA: Cost Per Action.

CPC: Cost Per Click.

CPM: Cost Per Thousand.

CSV: Comma-separated values.

CTPhone: City phone; a CAMTEL service branch for mobile telecommunications.

DOM: Document Object Model, a platform- and language-neutral interface for interacting with objects in HTML, XHTML and XML documents.

ECA: Economic Commission for Africa.

GDP: Gross Domestic Product.

GPS: Global Positioning System. It is a space-based satellite navigation system that provides precise positional and velocity data and global time synchronization for air, sea, and land travel.

GSM: Global System for Mobile Communications.

HIV: Human immunodeficiency virus.

HIVSA: South African non-profit organisation established in March 2002. It offers comprehensive therapeutic care to those individuals infected with and affected by HIV/AIDS, as well as their families (especially those living in impoverished circumstances).

HTML: Hypertext Markup Language.

HTTP: Hypertext Transfer Protocol.

ICT: Information and Communication Technology.

IIS: Internet Information Services, a web server application created by Microsoft for hosting .NET applications.

IndexedDB: Indexed Database.

iOS: Mobile operating system developed and distributed by Apple Inc, formerly called iPhone OS.

IP: Internet Protocol.

ITU: International Telecommunications Union.

IWD: Indigenous Weather Data.

Java ME: Java Platform, Micro Edition.

JSON: JavaScript Object Notation.

LTE: Long Term Evolution. It is a standard for wireless data communications technology.

MCT: Multipurpose Community Telecentre.

mHIMSS: Mobile Healthcare Information and Management Systems Society.

MINEP: Ministère de l'Environnement et de la Protection de la Nature.

MINFOF: Ministère des Forêts et de la Faune.

MINPOSTEL: Ministry of Posts and Telecommunications.

MMA: Mobile Marketing Association.

MTN Group: South African multinational mobile telecommunications company, operating in many African and Middle Eastern countries.

NICI: National Information and Communication Infrastructure.

Orange: French mobile telecommunications company.

OS: Operating System.

RIA: Research ICT Africa.

Safaricom: A Kenyan mobile network.

SDK: Software Development Kit.

SIM: Subscriber Identity Module or Subscriber Identification Module. It is an integrated circuit that securely stores the International Mobile Subscriber Identity and the related key used to identify and authenticate subscribers on mobile telephony device.

SMS: Short Message Service.

TRB: Telecommunications Regulatory Board, the body in charge with monitoring and following up the activities of telecommunications operators and services providers in Cameroon.

US: United States.

WWO: World Weather Online.

XML: Extensible Markup Language.

Bibliography

Print Resources

Aker, J. C. and I. M. Mbiti. *Mobile Phones and Economic Development in Africa*. Journal of Economic Perspectives 24 (2010), pp. 207–232.

Anderson, J. G.: *Professional Flash Lite® Mobile Development*. Wiley Publishing, Inc., Indianapolis 2010.

Anthes, G.: *HTML5 Leads a Web Revolution*. Communications of the ACM 55 (2012) No. 7, pp. 16-17.

Cam00: *Law No. 2000/011 of December 19, 2000 on Copyright and Neighbouring Rights*. Yaoundé 2000.

Cam10: *Law No. 2010/012 of 21 December 2010 Relating to Cybersecurity and Cybercriminality in Cameroon*. Yaoundé 2010.

Chen, P.: *The Entity-Relationship Model - Toward a Unified View of Data*. ACM Transactions on Database Systems 1 (1976) No. 1, pp. 9-36.

Cooper, A., R. Reimann and D. Cronin: *About Face 3: The Essentials of Interaction Design*. Wiley Publishing, Inc., Indianapolis 2007.

Dayang, P. and R. Siafaka: *A Mobile Commerce Solution for Sub-Saharan Countries such as Cameroon* in K. Jonas, I.A. Rai, and M. Tchuente (Eds.): AFRICOMM 2012, LNICST 119. Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, Springer 2013, Yaounde 2012 pp. 153-162.

Dayang, P. and R. Siafaka: *A Mobile API Solution for Localised Weather Forecast Representation* in Logothetis M. D., Glabowski M. And Krstic D. (eds) AICT 2013. The Ninth Advanced International Conference on Telecommunications, June 23 - 28, Rome 2013, Italy, 56-60.

eLearning Africa: *The eLearning Africa 2012 Report*. International Conferences, Workshops and Exhibitions, ICWE 2012.

Futrell, R. T., D. F. Shafer, and L. I. Shafer. *Quality Software Project Management*. Prentice Hall Int., Harlow, GB 2002.

Fling, B.: *Mobile Design and Development*. O'Reilly Media, Inc., 1st ed., Sebastopol CA 2009.

Hoare, C. A. R.: *The Emperor's Old Clothes*. Communications of the ACM 24 (1981) No. 2, pp. 75-83.

Hoober, S. and E. Berkman: *Designing Mobile Interfaces*. O'Reilly Media, Inc., 1st ed., Sebastopol CA 2012.

Hug, T.: *Didactics of Microlearning. Concepts, Discourses and Examples*. waxmann, Münster 2007.

Isaacs, S, D. Hollow, A. Akoh, and T. Harper-Merrett: *2013 Findings from the eLearning Africa Survey 2013.*, in Isaacs S (ed) 2013. The eLearning Africa Report, ICWE: Germany.

IEEE: IEEE Std 610.12-1990. *IEEE Standard Glossary of Software Engineering Terminology*. Los Alamitos, CA: IEEE Computer Society Press.

INS JIF: *Journée internationale de la femme, 27ème édition. Automiser les femmes rurales pour éradiquer la faim et la pauvrété*. INS, Mars 2012.

ITU: *International Telecommunication Union: The world in 2010. ITU World Telecommunication/ICT Indicators database*. International Telecommunication Union, Geneva 2010.

Jones, M. and G. Marsden: *Mobile interaction design* John Wiley Sons Ltd, Chichester 2006.

Kignaman-Soro, A.: *International Cooperation and Role of THORPEX in the Developing World*. The First THORPEX International Science Symposium. Montreal, Canada, December 2004

Kolyang: *Parlons Tpuri*. L'Harmattan, October 2010.

Kolyang: *Transformational Impacts of Computer Science on Third World Societies*. Habilitationsschrift, University of Bremen 2005.

LCC Cameroon: *Law No. 2010/012 of 21 December 2010 Relating to Cybersecurity and Cybercriminality in Cameroon*. Yaounde 2010.

LIP Cameroon: *Law No. 2000/011 of 19 December 2000 on Copyright and Neighboring Rights*. Yaounde 2000.

Maamar, Z.: *Commerce, E-Commerce, and M-Commerce: What Comes Next?*. Communications of the ACM 46 (2012) No. 12ve, pp. 251-257.

Meli, V:*Bayam Sellam market women and rural highway insecurity in Cameroon* in International Forum for Rural Transport and Development. IFRTD, London 2007.

Mensah, A. O., A. Bahta and S. Mhlanga: *E-commerce challenges in Africa: issues , constraints, opportunities*. Briefing Paper. Economic Commission for Africa 2006.

Myers, G. J. *The Art of Software Testing*. Wiley, New York, NY 1979.

Mobile Marketing Association: *Mobile Advertising Guidelines*. MMA, 1st ed, New York 2009.

Mobile Marketing Association: *Global Code of Conduct*. MMA, New York 2008.

Mugoya, A.: *African Apps in a Global Marketplace: ideas, observations, tips and some gripes about the African app industry*. Asilia, Nairobi 2011.

Nana M., R. C.: *Evolving Payment Platform for Developing Countries*. Fourth International IEEE EAI Conference on e-Infrastructure and e-Services for Developing Countries, November 12-14, 2012 Yaounde, Cameroon.

NAICT07: *National Policy for the Development of Information and Communication Technologies*. Yaoundé, September 2007.

Naismith, L., P. Lonsdale, G. Vavoula and M. Sharple: *Report 11: Literature Review in Mobile Technologies and Learning*. Futurelab series, University of Birmingham 2004.

Oehlman, D. and S. Blanc: *Pro Android Web Apps. Develop for Android Using HTML5, CSS3 JavaScript*. Apress, New York 2011.

Pamo, E. T.: *Country Pasture/Forage Resource Profiles*. FAO, Dschang 2008.

Paul Budde Communication: *Cameroon - Telecoms, Mobile, Broadband and Forecasts*. MarketResearch.com, February 2012.

Pilgrim, M.: *HTML5: Up an Running*. O'Reilly Media, Inc., 1st ed., Sebastopol CA 2010.

Pressman, R. S.: *Software Engineering – A Practioner's Approach*. McGraw-Hill Int. Ed., 7th ed., New York 2010.

Rao, M.: *Mobile Africa Report 2011: Regional Hubs of Excellence and Innovation*. extensia, 2011.

Sharpe, M.: *Climbing the e-waste mountain*. Journal of Environmental Monitoring 7 (2005) Climbing the e-waste mountain, pp. 933-936.

Shelly, G. B., T. J. Cashman, H. A. Napier and P. J. Judd: *Discovering the internet: complete concepts and techniques*. Thosom Course Technology, 2nd ed., Boston 2008.

Sommerville, I.: *Software Engineering*. Pearson, 9th rev. ed., Amsterdam 2011.

Sommerville, I and P. Sawyer: *Requirements Engineering: A Good Practice Guide*. John Wiley Sons, Chichester, England 1997.

Stair, R. M. and G. W. Reynolds: *Information Systems*. Course Technology, 10th ed. 2012

Stark, J.: *Building Android Apps with HTML, CSS, and JavaScrip*. O'Reilly Media, Inc., 1st ed., Sebastopol CA 2010.

Tchakounte, F. and P. Dayang: *System Calls Analysis of Malwares on Android*. In International Journal of Science and Technology 2 (2013) No.9, pp. 669-674.

Telecommunications Regulatory Board. *Informations statistiues sur le marché de la téléphonie (premier et deuxème trimestre 2011)*.TRB, Yaoundé 2011.

Tonye, E.: *Développement des Télécommunications au Cameroun à l'horizon 2035*. FOSTDIC, Dortmund 2012.

Wame, B.: *Internet au Cameroun: les usages et les usagers. Essai sur l'adoption des technologies de l'information et de la communication dans un pays en voie de développement*. Thèse de doctorat, Université de Paris II, 12 décembre 2005.

Waverman, L., M. Meschi and M. Fuss: *The Impact of Telecoms on Economic Growth in Developing Countries*. Vodafone Policy Paper Series, 2, 10-23, 2005.

Wiegers, K.E.: *Software requirements.: Practical techniques for gathering and managing requirements throughout the product development cycle*. Microsoft Press, 2nd ed., Washington 2003.

Zhou, Y., Jiang, X.: Dissecting Android Malware: Characterization and Evolution. Proceedings of the 33rd IEEE Symposium on Security and Privacy (Oakland 2012), San Francisco, CA, May 2012.

Online Resources

ACDI: *Scandale au Ministère des Transports*. http://www.acdic.net/ACDIC/component/k2/itemlist/tag/comice%20agropastoral. Visited on 18.01.2013.

Africa Health IT News: *Mobile Health* http://africahealthitnews.com/blogs/?category_name=mobile-health. Visited on 18.04.2012.

Africa eLearning: *News Portal Perspectives on ICT and Education in Africa*. http://www.elearning-africa.com/eLA_Newsportal/. Visited on 22.04.2012.

AUC: African Undersea Cables. http://manypossibilities.net/african-undersea-cables/. Visited on 31.05.2013.

Android: *Android API Guides, User Interface*: http://developer.android.com/guide/topics/ui/index.html. Visited on 25.08.2012.

webdesignerdepot: *Best practices for navigation on the mobile web* http://www.webdesignerdepot.com/2012/11/best-practices-for-navigation-on-the-mobile-web Visited on 7.08.2013.

BITKOM: *83 Millionen Alt-Handys*. http://www.bitkom.org/de/markt_statistik/64046_70811.aspx. Visited on 16.04.2012.

cameroononline.org: *Mobile Banking in Cameroon Increases Access to Financial Service*. http://www.cameroononline.org/2012/03/15/mobile-banking-in-cameroon-increases-access-to-financial-services. Visited on 15.03.2012.

CIA. *The World Factbook. Africa :: Cameroon* https://www.cia.gov/library/publications/the-world-factbook/geos/cm.html. Visited on 12.08.2013.

CIN: *Télécommunications: 205 télécentres opérationnels d'ici fin 2013* http://www.cameroon-info.net/stories/0,44685,@,telecommunications-205-telecentres-operationnels-d-ici-fin-2013.html . Visited on 23.04.2013.

Choudhary, S. R.: *Automated Discovery of Cross-browser Incompatibilities in Web Applications*. Georgia Institute of Technology, Atlanta, GA http://src.acm.org/2012/ShauvikRoyChoudhary.pdf. Visited on 8.02.2013.

CCSPM: *La Météo de la météorologie camerounaise : La météorologie au Cameroun est morte*. https://groups.google.com/group/sgp-cmr-network/attach/58832513b5bf6241/Communiqu%C3%A9_CCSPM_M%C3%A9t%C3%A9o_Cameroun.pdf?part=4. Visited on 20.01.2013.

CRTV: *Mobile Phone Services: Vietnam's Viettel takes third place.* http://www.crtv.cm/cont/nouvelles/nouvelles_sola_fr.php?idField=11940&table=nouvelles&sub=national. Visited on 17.01.2013.

DCM: *Data Center Map. Internet Exchange Points.* http://www.datacentermap.com/ixps.html. Visited on 16.04.2013.

Endong, H. B: *Internet: Environ 7% de taux de pénétration au Cameroun en 2011 - Le Cameroun reste au bas de l'échelle continentale.* http://www.cameroon-info.net/stories/0,32691,@,internet-environ-7-de-taux-de-penetration-au-cameroun-en-2011-le-cameroun-reste-.html. Visited on 22.3.2012.

Engelbrecht, W.: *Mobile Healthcare: The African diagnosis.*http://vomo.co.za.dedi121.flk1.host-h.net/mobile-healthcare-the-african-diagnosis/. Visited on 12.06.2012.

FAO: Food and Agriculture Organization of the Unites Nations. *Agricultural map of Cameroon* http://www.fao.org/ag/AGP/AGPC/doc/Counprof/cameroon/figure7.htm

Falk, M.: *Mobile Frameworks Comparison Chart* . http://www.markus-falk.com/mobile-frameworks-comparison-chart/. Visited on 19.01.2013.

Google Developers: *Chrome Developer Tools.* https://developers.google.com/chrome-developer-tools/docs/profiles. Visited on 17.01.2013.

Gruber, H. and P. Koutroumpis: Economic Policy. *Mobile Telecommunications and the Impact on Economic Development*, EIEF, 22-23 October 2010. http://dev3.cepr.org/meets/wkcn/9/979/papers/Gruber_Koutroumpis.pdf. Visited on 13.08.2013.

HIMSS: *mHIMSS Apps.* http://www.mhimss.org/resource-topics/apps. Visited on 22.04.2012.

HTML5: *HTML5 features storage.* http://www.html5rocks.com/en/features/storage. Visited on 23.08.2012.

HTML5: *HTML5 rocks tutorials.* http://www.html5rocks.com/en/tutorials/speed/html5/. Visited on 17.01.2013.

InMobi: *Mobile commerce in Africa showing signs of record growth*, BizReport: Mobile Marketing: June 21, 2011. http://www.bizreport.com/2011/06/mobile-commerce-in-africa-showing-signs-of-record-growth.html. Visited on 22.04.2012.

INS: Institut National de la Statistique du Cameroun: *Annuaire statistique 2011.* http://www.statistics-cameroon.org/news.php?id=83. Visited on 22.01.2013.

IST-Africa: Introduction - Republic of Cameroon http://www.ist-africa.org/home/default.asp?page=doc-by-id&docid=5183. Visited on 15.08.2013.

Java ME: *What is J2ME or Java ME?*.http://java.com/en/download/faq/whatis_j2me.xml. Visited on 05.01.2013.

Jeune Afrique: *Innondaions meurtrières au Cameroun et au Nigéria*. http://www.jeuneafrique.com/Article/ARTJAWEB20120913122017. Visited on 13.01.2013.

Jeune Afrique: *Cameroun: un petit pas pour les internautes*. http://www.jeuneafrique.com/Article/ARTJA-F2F327B8C2226/cameroun-internet-camtel-faicameroun-un-petit-pas-pour-les-internautes.html. Visited on 13.01.2012.

mylookout: Lookout Mobile Threat Report August 2011. www.mylookout.com/_downloads/lookout-mobile-threat-report-2011.pdf Visited on 1.07.2013.

Minpostel: *Présentation du projet des télécentres*. http://www.minpostel.gov.cm/index.php/en/les-projets/telecentres Visited on 22.06.2012.

Ministry of Trade: *The concept of metrology*. http://www.mincommerce.gov.cm/mincommerce.php?lang=en&launch=76fe97759aa27a0

Mensah, A. O., A. Bahta and S. Mhlanga: *E-commerce challenges in Africa: issues, constraints, opportunities. United Nations Economic Commission for Africa 2006*. http://www.uneca.org/aisi/docs/PolicyBriefs/E-commerce$%$20challenges$%$20in$%$20Africa.pdf. Visitied on 10.10.2012.

monetizepros: *How To Sell Display Ads: CPM vs. CPC vs. CPA*. http://monetizepros.com/blog/2013/how-to-sell-display-ads-cpm-vs-cpc-vs-cpa/. Visited 17.08.2013.

mPedigree Network: *We Are the mPedigree Network*. http://www.mpedigree.net/mpedigree/index.php. Visited on 19.04.2012.

MTN Group Limited: *Subscriber and Average Revenue per User (ARPU) Number for the quartier ended 31 march 2012*. http://www.mtn.com/Investors/Financials/QuaterlyResults/MTN_Release_of_subscriber_numbers_for_the_quarter_ended_31_March_2012.pdf. Visited on 17.01.2013.

Mulpuru, S., C. Johnson and D. Roberge: *US Online Retail Forecast, 2012 To 2017*. http://www.forrester.com/US+Online+Retail+Forecast+2012+To+2017/fulltext/-/E-RES93281?objectid=RES93281. Visited on 24.10.2013.

NAICT: *National Agency for Information and Communication Technologies* http://www.antic.cm. Visited on 03.01.2013.

Oehlman, D: *iPhone and Android Web Application Frameworks*. http://www.distractable.net/coding/iphone-android-web-application-frameworks. Visited on 19.01.2012.

pcworld.com: *US Man to Serve Prison Term for Selling Counterfeit Software*. http://www.pcworld.com/article/174222/article.html. Visited on 25.01.2013.

PhoneGap: *Supported Features*. http://phonegap.com/about/feature/. Visited on 19.01.2013.

Safaricom: *M-PESA Growth*. http://www.safaricom.co.ke/mpesa_timeline/timeline.html. Visited on 30.04.2012.

sasayez.com: *The concept of sasayez.com*. http://www.sasayez.biz/concept-sasayez-com. Visited on 13.01.2013.

Statistiques mondiales *Mobile Banking in Cameroon Increases Access to Financial Service*. http://www.statistiques-mondiales.com/cameroun.htm. Visited on 15.03.2012.

Telecommunications Regulatory Board: *The tasks of Telecommunications Regulatory Board*. http://www.art.cm:81/index.php?option=com_content&task=view&id=5&Itemid=66. Visited on 12.06.2012.

T-Online: *Datenoptionen. Günstig surfen und emailen*. http://www.t-mobile.de/tarifoptionen/0,20406,17775-_3087,00.html. Visited on 17.04.2013.

Vijaygauri, G,: *Capucci F. Test Case Writing (Creation) 101* http://help.utest.com/testers/crash-courses/functional/test-case-writing-creation-101. Visited on 08.11.2013.

W3C: *Web Storage. Editor's Draft 26 July 2012*. http://dev.w3.org/html5/webstorage/#storage. Visited on 24.08.2012.

Shukla, R.: *Mobile phone charges GDP growth*. http://economictimes.indiatimes.com/opinion/view-point/mobile-phone-charges-gdp-growth/articleshow/7861551.cms. Visited on 13.08.2013.

Nielsen, J.: *Usability 101: Introduction to Usability*. http://www.nngroup.com/articles/usability-101-introduction-to-usability/, January 4, 2012. Visited on 18.10.2013.

WorkLight Webinar Series: *Native, Web or Hybrid Mobile App Development*.http://www.worklight.com/resources/webinars-and-tools/native-web-hybrid-mobile-app-development. Visited on 19.08.2012.

WWO: *World Weather Online*..http://www.worldweatheronline.com. Visited on 20.01.2013.

A Main Services of mobile Operators in Cameroon

The major services offered by MTN, Orange and CAMTEL are listed in Table A.1. Each table provides information on the service name, a short description of the essential features, and it says if the service is free or charged.

MTN

Package	**Description**	**Accessibility**
MTN Bip Me	Send a SMS even without airtime	free
MTN Me2U	Transfer airtime from one account to another	sender's account is debited by 5% of the transferred amount
MTN Fifty-Fifty	Conference Call	Participants share the communication cost
Y'ello night	Off-peak tariff	1 FCFA/s from 22h00 to 5h:59
MTN Save My Contacts	Save entire SIM book at MTN	free
MTN Mobile Money	Send/receive mobile money, pay bills and do purchases, buy airtime	cost per transaction
MTN Mobile Office	Remote access via VPN interconnection to emails, databases etc.	cost monthly
MTN Fax Mail / Data Fax	Receive fax on mobile phone	charged
MTN data Link	Accessing your office LAN and email, sending and receiving faxes	charged
MTN Mobile Internet	Access to Internet via a USB plugged with a SIM card	cost per hour, day, week or month

Table A.1: Main MTN services

ORANGE

Package	Description	Accessibility
Info kiosk	Receive daily national and international news	charged
Chat Kiosk service	Online virtual discussion forum	charged
Kiosk Orange culture: 960	Participate to interactive radio and TV programmes by dealing a specific number	charged
Data / fax	Send / receive faxes or data	charged
Save your contacts	Save entire SIM book on Orange server	charged
Pay for me	The receiver pays the communication fees	cost per transaction
Mobile Internet	Remote access via VPN interconnection to emails, databases etc.	cost monthly
Push email	Receive an alert for incoming emails, read and send emails	charged
Call me back	Send a free SMS, but at least 230 F as airtime in the phone	free
Mobile Internet	Access to Internet via a UBS plugged with a SIM card	cost per hour, day, week or month
Orange Money	Paying bills, sending and receiving money, bying airtime	charged

Table A.2: Main Orange services

CAMTEL

The CAMTEL offer comprises :

- Internet connection
- Enterprise network
- Fixed wireline telephony
- Mobile telephony called CTPhone

Its focus is on the Internet access for enterprises and governmental institutions in particular. It is worth noting that the Internet connectivity is not yet stabilised, it is characterised by regular disconnections, which may last many days. Six options of Internet connection are available:

1. **Wireline Copper DL (Optical fibre)**: A Dedicated Internet Line with very high speed in gigabyte per second (Gbps) on fibre optic.

2. **ADSL**: Asymmetric Digital Subscriber Line; it allows a speed between 64 Kbit/s and 8 Mbit/s. It requires a fixed wireline.

3. **CTPhone**: Internet connection via a USB stick with a speed up to 236 Kbit/s.

4. **EVDO**: EVolution Data Optimised; type of Internet connection with a speed up to 3.1 Mbit/s or 9.3 Mbit/s. It is a wireless connection via a USB device.

5. **DIAL-UP or PSTN**: Public Switched Telephone Network, the most used connection type for home Internet via a moden with a speed up to 56 Kbit/s. It requires a fixed wire-line.

6. **WIMAX**: Worldwide Interoperability for Microwave Access for home, enterprises etc.; it is wireless and allows a speed from 128 Kbit/s to 2 Mbit/s.

B List of important African apps

We do not provide a comprehensive examination of mobile phone services and applications in Africa, but rather explore some current services in some key areas. We orient ourselves according to the Web portal selection criteria, which stipulate that the app is:

- a good idea,
- impressively designed,
- innovative functionality,
- unique or first of its kind,
- popular among users.

Mobile Banking Mobile banking or mBanking is a term that describes the activity of performing account transactions, balance checks, credit applications, payments and other banking transactions through a mobile device such as a mobile phone. Here, bellow are some examples of mobile apps and services.

1. MPesa

MPesa, composed of "M" for mobile and "Pesa" for "money" in the Swahili language, it is a SIM app for money transfer application and service available in Kenya.

Motivation: Trigger of this app is to create a service which allowed microfinance borrowers to conveniently receive and repay loans using the network of Safaricom airtime reseller. **Features:** This app encompasses services such as:

- Deposit and withdraw money
- Check drugs availability
- Pay bills
- Purchase airtime
- Transfer money to both users and non-users of MPesa

Effect: This banking service for non-banked people started in Kenya and is now available in many other countries such as Tanzania, Afghanistan, South Africa etc.. March 2012, M-Pesa had over 14,6 million subscribers in Kenya and takes in charge a network of over 28,000 agents across Kenya [Safaricom 2012].

Technical and organisational requirement: MPesa is SIM dependent, i.e., it depends directly on the mobile operator.

2. MPayer is another mobile phone application. It offers mostly similar functions as MPesa such as receiving and transferring money. The trigger motivation was to end the *cheque-in-post* culture that has ruined many small African firms, often operating on tiny margins with little or no access to bank credit.

Mobile Health

According to Peter Benjamin, the main issue while using mobiles is not how to make them do amazing things in the hands of wealthy citizens; but rather if the phones in the hands of the youths and adults can be turned into an effective tool for supporting healthcare [Engelbrecht 2012]. Regarding the area of mobile health a range of services or apps exists. Current apps will be analysed based on both their societal features and the technical realisation approach.

1. MPedigree from Ghana

MPedigree is a mobile phone service that has been developed to tackle the problem of medicine counterfeitness.

Motivation: Actually, the World Health Organization (WHO) has estimated that up to 30% of medicines sold in Africa are suffering of counterfeitness, and the trade of fake drugs is putting millions of human lives at risk every year. A safe reliable treatment become a hit-and-miss affair.

Features: Customers buying any medicine are asked to scratch off a verification strip on the packaging which reveals a numeric code. They send the numeric code to a central registry to query pedigree information of product brands belonging to participant manufacturers, and stored in the registry. MPedigree confirms via a reply SMS with the manufacturer if the goods are genuine or not.

Effect: An important side effect of this effort is the steady recovery of the more than $200 million that legitimate pharmaceutical companies daily lose to this genocidal trade. Presently, this service is provided only in one country, Ghana, and free of charge.

Technical and organisational requirement: Beyond holding a mobile phone, this service requires undeniable network.

2. hi4LIFE from South Africa

hi4LIFE is a twofold mobile service which provides health information. On the one hand it is a set of customized mobile Websites, and on the other hand a SMS service.

Motivation: In South Africa, the mortality of children under the age of five is increasing. There is a high rate of adolescent pregnancy, and the majority of South African living with HIV are females. To counter this problem, the South African non-profit organisation called HIVSA decided to provide mHealth helping to inform, educate and communicate with the public and sharing materials.

Features: Using web-enable mobile phones to access information, education and communication materials on various health topics including HIV, mother & child health from three different Websites which are *mama.mobi* for girls, women and mothers; *papa.mobi* for boys, men and dads; *baby.mobi* for everyone looking after infants. Moreover, to access the hi4LIFE mHealth services, a public number is dialled, which directs the caller to various information menus, through which a topic of interest can be selected. In return, the caller will receive a set of SMS on the selected topic.

Technical and organisational requirement: Beyond holding a mobile phone, this service requires undeniable network connectivity for sending SMS or navigating through the optimised Websites.

3. medAfrica from Kenya

medAfrica is a mobile health widget platform that aggregates different services and content related to health issues.

Motivation: The main idea is that doctors in Africa shall communicate with their patients through mobile phones.

Features: This native app is characterised by following features:

- Contacts of various doctors and their specialities
- Nearby hospitals
- Drugs availability
- Diet guide
- Symptoms guide

Technical and organisational requirement: The app runs as native application, both on Android and Symbian platform. It requires Internet connection whenever the user wants to get access to the features, because information is retrieved from a remote database server.

Mobile Agriculture

There exist approaches to support agriculture by means of mobile technology, even though existing mobile solutions are few.

1. MFarm from Kenya

MFarm is a SMS service that gives rural farmers a fairer deal when selling their produce.

Motivation: An initiative aiming to give rural farmers a fairer deal when selling their products.

Features: It gives real-time market prices for crops and matches up farmers with buyers, cutting out costly brokers and middle-men.

Effect: Presently, it is used only in Kenya, some Kenyan farmers report that their profits have risen by half since subscribing to mFarm.

Technical and organisational requirement: Farmers need airtime to send a SMS to a special number requesting product prices.

2. iCow from Kenya

iCow is a voice-based mobile cow calendar. It helps farmers to manage the breeding cycles of their dairy cows.

Motivation: Providing to the farmers a portable, affordable and user friendly software application to manage their cattle.

Features: It enables small scale farmers to access agricultural information and services over the mobile phone. It gives the farmers access to updated data on their cow's gestation period and other dynamics related to health and nutrition.

Technical and organisational requirement: Cattle farmers owning mobiles use their airtime to send a SMS to a special number for accessing information over mobile device. Communication is done via SMS.

Mobile Learning

The *mobile*, i.e., *ubiquitous* aspect of devices improves the fact that learning can take place any time and anywhere, whether formally or informally. We define mobile learning *mLearning* as the process of acquiring any knowledge and skill through using mobile technology, anywhere, anytime. In Africa, the ratio of mobile subscribers to fixed lines is 15:1. The ubiquitous characteristic of mobile devices or applications claims mLearning process. Mobiles are an affordable and realistic channel for knowledge transmission in most African countries.

Mobile technologies have produced new learning environments and practices that Naismith et al. (2005) have summarised as follows:

1. **Behaviourism:** mobile devices support activities that promote learning as a change in learners' observable actions. They influence learners' behaviour and are themselves learning object.

2. **Constructivism**: learners can use mobile to actively construct new ideas or

concepts based on both their previous and current knowledge, also indigenous knowledge.

3. **Situated learning**: mobiles are ubiquitous and can easily support activities that promote learning within an authentic context and culture.

4. **Collaborative learning**: mobiles support various social networking services, which facilitate activities that promote learning through social interaction.

5. **Informal and lifelong**: again, the ubiquity of mobile devices provides substantial support for activities that support learning outside a dedicated learning environment and formal curriculum.

6. **Learning and teaching support**: finally, mobile devices help in the coordination of learners and resources for learning activities.

Listing some apps

The analysis of apps listed in the table below leads to the fact that the majority of existing apps are native apps and operate offline or they are totally depending on the Internet connectivity.This may incur huge possible charges. Hybrid applications, those that can operate offline as well as online, are almost non-existent.

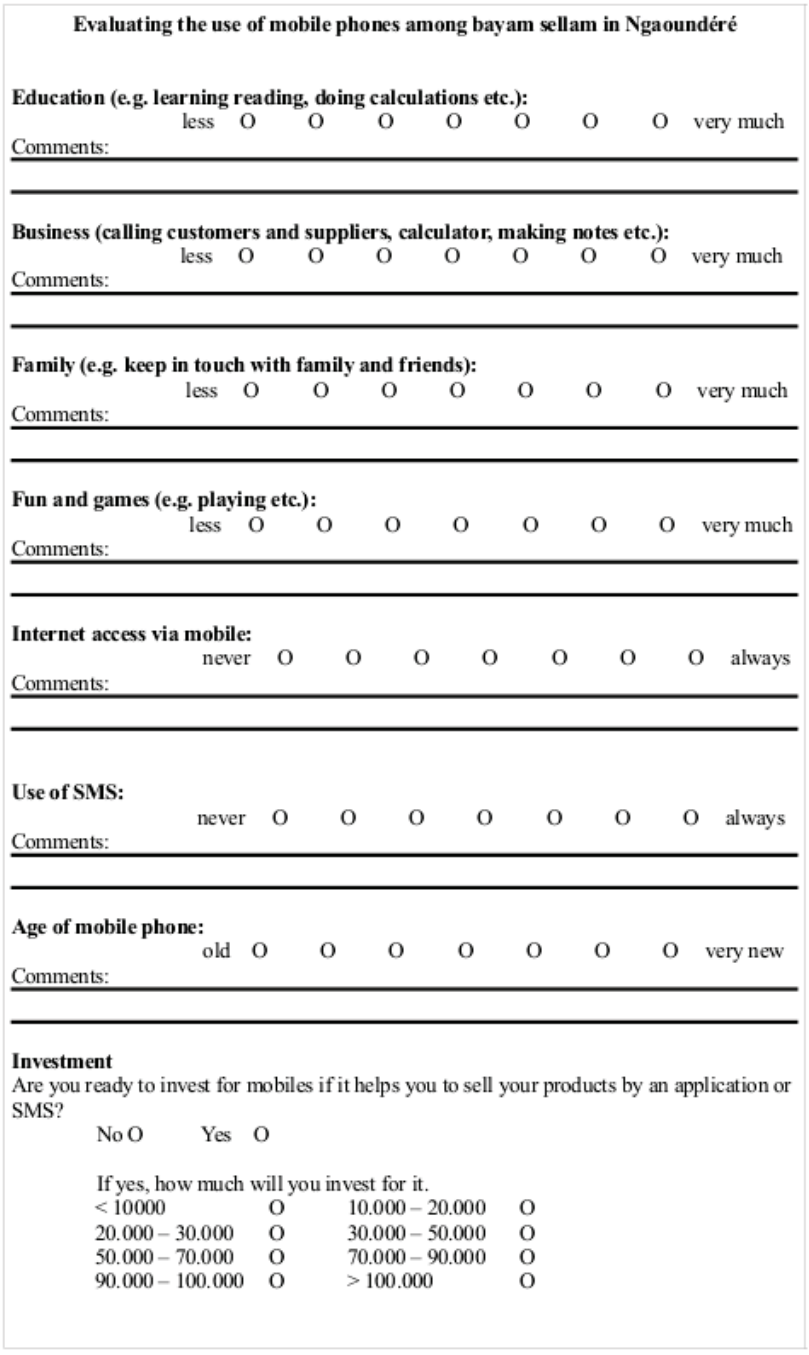
The table encompasses the attributes: *name*, short *description*, application type, i.e., *native*, *Web* (customized Website), *hybrid* (Web and native). Furthermore, we also specify if the app requires SIM-dependent or Internet-dependent (*ON*, *OFF*). SIM-dependent apps are those that require a specific mobile operator and Internet-dependent those that need a undeniable Internet connection for data traffic.

Name	Native	Web	Hybris	SIM	ON	OFF	Description
Yoruba	x					x	App contains basic phrases of Yoruba language, for finding yourself in Nigeria.
Hummba	x				x		Social and travel Website for downloading free audio, sharing travel experiences.
Zing	x				x		Multi-messenger for keeping in touch with friends.
Défarlou	x					x	Ordering management application for small business owners.
M-Farm		x			x		Helping farmers to inquire current market prices for their product.
Ayo	x					x	A board game popular in West and Central Africa.
Eat Out		x			x		Restaurant guide with a listing of restaurants around Kenya and Tanzania.
Ayo Mobile	x					x	Traditional strategy game, popular in West Africa and other parts of Africa.
Safindit	x				x		Locating accommodation, restaurants, plumbers, clubs etc. around South Africa.
Simple Zulu 1	x					x	learning basic Zulu language on flash cards.
Jigsaw	x					x	Fun puzzle game that stimulates problem solving skills.
Untying the Knot	x					x	Telling story of two giraffes.
Abel with no Navel	x					x	Children's story about a penguin.
WHOT!	x					x	Card game for all ages.
Hemmed In	x					x	Fun game of strategy.
Torch Burst	x					x	Addictive bubble burst arcade game.
MedAfrica	x				x		Platform for patients and their doctors to communicate.
Olalashe	x				x		Geo-alert application helps to communicate when in trouble.

Name	Native	Web	Hybris	SIM	ON	OFF	Description
Afrinolly	x				x		Retrieving African movies and clips from various sources.
iCow			x	x	x		Mobile cow calendar, acting as a farmers mobile management tool via SMS.
Wakanow	x				x		Providing travellers to research, plan, and book their travel needs in Nigeria.
Nkyea Twi Phrasebook	x					x	Learning Twi language from Ghana interactively.
iWarrior	x					x	Game that puts player in the role of protecting his village.
Gripeline		x		x			For companies to communicate with customers feedback via Web interface & SMS.
Mobiflock	x				x		For parents to monitor and manage their children's phone.
Cheki.co.ke	x				x		Car classifieds/directory platform for advertising in East African.
iScribe	x				x		Enable creating and sharing stories or blog/journal entries and include photos, audio and video clips.
Tuvitu	x				x		Customising and personalising the information browsed/received via mobile phone.
Zoopy	x				x		Displaying the latest news, sports and entertainment from South Africa and the world.
Mocality		x			x		Mobile-based business directory for searching by using SMS commands.
M-Pesa				x		x	Mobile-to-mobile money transfer application/service available in Kenya.
Tweetwallsaver	x				x		Photo gallery browser, allowing to post and view tweets.
iSenegal	x				x		Directory of businesses and services in Senegal.
Basic Swahili	x					x	Learning Swahili language interactively.
My Twi Name	x				x		Help to know and say own Twi name - nickname in Ghana -.

Table B.1: African market of apps at a glance

C The Questionnaire



Evaluating the use of mobile phones among bayam sellam in Ngaoundéré

Education (e.g. learning reading, doing calculations etc.):
less O O O O O O O very much
Comments:

Business (calling customers and suppliers, calculator, making notes etc.):
less O O O O O O O very much
Comments:

Family (e.g. keep in touch with family and friends):
less O O O O O O O very much
Comments:

Fun and games (e.g. playing etc.):
less O O O O O O O very much
Comments:

Internet access via mobile:
never O O O O O O O always
Comments:

Use of SMS:
never O O O O O O O always
Comments:

Age of mobile phone:
old O O O O O O O very new
Comments:

Investment
Are you ready to invest for mobiles if it helps you to sell your products by an application or SMS?
No O Yes O

If yes, how much will you invest for it.

< 10000	O	10.000 – 20.000	O
20.000 – 30.000	O	30.000 – 50.000	O
50.000 – 70.000	O	70.000 – 90.000	O
90.000 – 100.000	O	> 100.000	O

Figure C.1: Questionnaire for eliciting Bayasella Requirements