# Multi - Agent System (MAS) based simulation of Mobile Bulletin Board (MBB) adoption.

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**Abstract**
Information dissemination through mobile information and communication technology (MICT), is promising to bring Sub Saharan Africa (SSA) into par with the rest of the world. The advent of mobile bulletin boards (MBB) means that, with minimum available technology, anybody anywhere in the world can be a traceable source of information. The question we ask for this work is: how can we study the growth rate of adopting MBB? In this paper we present a graph based model of the social network phenomenon - mobile bulletin boards. We simulate the phenomenon using multi-agent systems (MAS) and use NetLogo as a simulation tool for this work. The paper concludes with a discussion on the results of the simulation and some perspectives for future work to be carried out in related areas.

**Key Words**
Mobile Bulletin Board (MBB), NetLogo, MICT, Graph theory, Bipartite graph, Sub Saharan Africa (SSA), Multi-agent Systems (MAS), Agent Based Modelling and Simulation (ABMS), Short Messaging Services (SMS), Literacy rate

## Introduction

A mobile bulletin board (MBB) is an electronic platform on which information is posted and accessed via mobile phones [13]. The trends in bulletin board communication, has advanced from paper based (notice boards), through electronic based (web sites) to mobile bulletin boards (dot me) [14]. An implementation of this phenomenon by Etisalat Nigeria presents a scenario where a “doter” - anyone subscribed to their mobile phone network, can post a message on his/her MBB and “followers” - any mobile phone subscriber anywhere in the world with short messaging services (SMS) capabilities can access the message.
In every age, the adoption and usage of this salient media for information dissemination has had its successes, challenges and failures. In sub Saharan Africa (SSA), MICT is promising a more reliable medium for information propagation [15]. MBB requires a minimum literacy rate for its adoption, growth and success. It will be a test, challenge and reflection of SSA's attainment to par with the rest of the world in information production and consumption.
A question we ask is: how can we study the growth rate of adopting this technology? Given that the study involves a wide geographic area with a dynamic population, it will be unrealistic for evaluation to be done based on a survey instrument. In line with other researchers [7, 8, 11], we have resorted to Agent Based Modelling and

Simulation (ABMS). ABMS provides multiple possibilities and options to work with large scale homogeneous/heterogeneous population, to closely reflect different aspects of reality in virtual space.
In carrying out this research, we ask the question: What is the growth rate of "doters" within a sample population. The answer to this question and the implication of this study can be very useful to the general public in the way information is produced, managed and consumed.
Reviewing a wide variety of publications involving multi-agent systems, agent based modelling and simulation, computational sociology, we created and developed a graph based model for the phenomenon: mobile bulletin boards. We are working on a NetLogo simulation of the model and are presenting our initial findings.

**Literature Review**
To circumvent the body of knowledge necessary to address the problem, we begin by addressing social phenomenon. We look at relationships within the global village, addressing nearness as a concept as well as the pull concept. We reviewed works on automated proofs, mathematical modelling and multi-agent systems simulation.

Dealing with language and the problem of communication within a social community, Michal et al [4] set out to create a performing **conversational** system that would act as a language tutor. Commencing with Alen Turing's 1950 question - "Can machines think?", they focus on chatterbots as computer systems specialised in simulating intelligent conversations. Classifying chatterbots into task and non-task oriented groups, they identify the benefits and challenges posed by both groups and proceed to design a system that incorporates and enhances the advantages of both groups. The architecture of their system is built upon the baseline chatterbot (Modaline) with additional modules to perform supportive roles. They conclude that their work presents an insight on the roles conversational systems play to benefit the modern society.

Moving on to addressing a social community as a global village, where nearness is a concept as represented in a virtual space, Mehdi et al [7] present a model of informed virtual geographic environments (IVGE) [9] for the better understanding of social behaviours (Crowd phenomenon). They introduced (1) Social notions in agent models such as social identity and mechanisms that allow an agent to adopt a new identity under some conditions. (2) The notion of social group to which an agent may belong. (3) The notion of spatio-temporal group (STG) recognisable in space and time. (4) Mechanisms that allow an agent to join or leave a group. They present an architecture for generating IVGE from GIS data. Leveraging Newell's behavioural pyramid [8, 10], they propose three (individual, long term decision, social influence) successive behavioural categories to structure an agent in an STG. They simulate a demonstration event involving a large number of geo-referenced individual social agents immersed in an informed virtual environment representing Quebec City. Mehdi Mekni worked extensively with STG and IVGE to model crowd simulation in a MAS.

Addressing these social needs within the virtual world also raises some moral responsibilities. Keith et al [5] explore whether it is evil for a machine to masquerade as a human on the basis of the definition of good and evil as presented by Floridy et al [6] and how this impacts the info-sphere. They highlight ten moral actor/patient

relationships involving robots in the info-sphere and go further to analyse six of these relationships: the developer as actor, robot as patient; robot as actor, user as patient; user as actor, robot as patient; developer as actor, user as patient; robot-user as actor, others as patient; developer-robot as actor, others as patient. In each of these relationships, they draw a line for moral judgement of accountability / responsibility before concluding on its morality. They concluded that when a machine masquerades, it influences the behaviour or action of people not only towards the robots but also towards other people. In this paper, they have shown that machine masquerading makes it difficult to make sound decisions.

Having addressed the social aspects, Dennett [3] presents the use of mechanised theorem proving techniques / tools for handling a hard class of problems in economics. Exploring types of mathematical knowledge representation (semi-formal representation systems) and theorem provers such as Theorema or Leo, (fully automated) and Isabelle (interactive), they came up with a work plan that was illustrated using 2 lemmas. They conclude by seeking valuable contribution to their work in formalising a small area of theoretical economics.

A mathematical model of desire, need and attention is presented by Alexander [1]. Highlighting the lack of clarity in the concept and using a hedonistic approach to desire, he presents formulae of desire, draws a periodic / cyclical relationship between need and feeling and relates attention to hedonism. Analysing a single phenomenon (desire), he presents a hedonistic resolution of the frame problem and proceeded to multiple phenomena (attention). The frame problem has been described by Dennett as follows:

> What is needed is a system that genuinely ignores most of what it knows and operates with a well-chosen (well-chosen, but not chosen by exhaustive consideration) potion of its knowledge. How then can you give a system rules for ignoring - or better, since explicit rule-following is not the problem, how can you design a system that reliably ignores what it ought to ignore under a wide variety of different circumstances in a complex action environment.

He concluded by stating that his mathematical models are original, simple and intuitive and he believes that they can be accommodated in the design of autonomous systems.

Pergament et al [11], present a MAS based simulation to address an online social network (OSN) ethical issue - privacy management. They test / validate a friends oriented reputation privacy score (FORPS) system by using 'No FORPS' and 'FORPS+' as the lower and upper control limits for their FORPS model. Presenting mathematical formulae and equations for the simulation model, they identified four categories of agents: the requestors (R), the member (C1), the members (C2) and the rumours launcher (M). They modelled diffusion, meeting and information exchange. Using NetLogo [12], they simulated instantiation of an OSN and monitored some decision processes such as opinions, friends and convergence and reported on convergence, half-life and dangerous evaluation errors. They concluded by highlighting the limitations of their model - bootstrap problem, the no-model problem and simple simulation model problem and envisaged testing different versions of the FORPS model and planned to test the model with real users' problems.

**The Simulation Model**

Inspired by the work done in [12] by Mika, where he modelled an online social network is using an undirected graph $G = (V, E)$ in which the vertices $V$ or nodes represent the individuals and the edges $E$ represent a finite set of links between the individuals, such that $E$ is a subset of $V \times V$ . Here, we use a directed graph to model a pull phenomenon.

A graph model for the social network phenomenon, mobile bulletin board has the following characteristics:

1. The set of vertices $V$ is partitioned into two disjoint sets $V_1$ – set of individuals who have a mobile bulletin board and $V_2$ – set of individuals who do not have a mobile bulletin board. *Note that, in reality, an individual may belong to both sets*. It is a bipartite graph, every edge in the graph, connects a vertex in $V_1$ to a vertex in $V_2$.
2. The set of edges (E), consist of ordered pairs of vertices ($v_i$, $v_j$), such that $v_i$ is from the set of followers ($V_2$.) and $v_j$ is from the set of mobile bulletin board owners ($V_1$). *Note that, this reflects a pull concept of information dissemination as opposed to a push concept.* It is a digraph. The relationship between individuals in this social network phenomenon is directional.
3. The set of edges (E), may contain multiple entries of the same ordered pair. It is equally possible to have many individuals (potential / active followers) accessing contents from a multitude of others (mobile bulletin board owners). *Note that, a follower may request information from the same bulletin board multiple times.* It is a multi-graph.
4. There is no edge in the set (E), which begins and ends on the same vertex. For this model, an individual within this social network phenomenon has no traceable / influential relationship with him / herself. Note that, in reality bulletin board owners can access their own bulletin board. The graph model is loop-free.

In summary, the graph model we are proposing for the representation of this social network phenomenon is a bipartite, directed, multi-graph without loops. It is defined mathematically in the following three equations:

$G = (V, E)$ ----------Equation 1

Such that $V = V_1 \cup V_2$ ----------Equation 2
Where $V_1$ and $V_2$ form a partition of the set $V$

$E = \{(u_i, u_j) | u_i \in V_2 \wedge u_j \in V_1\}$ ----------Equation 3

**<u>The Modelling Tool</u>**

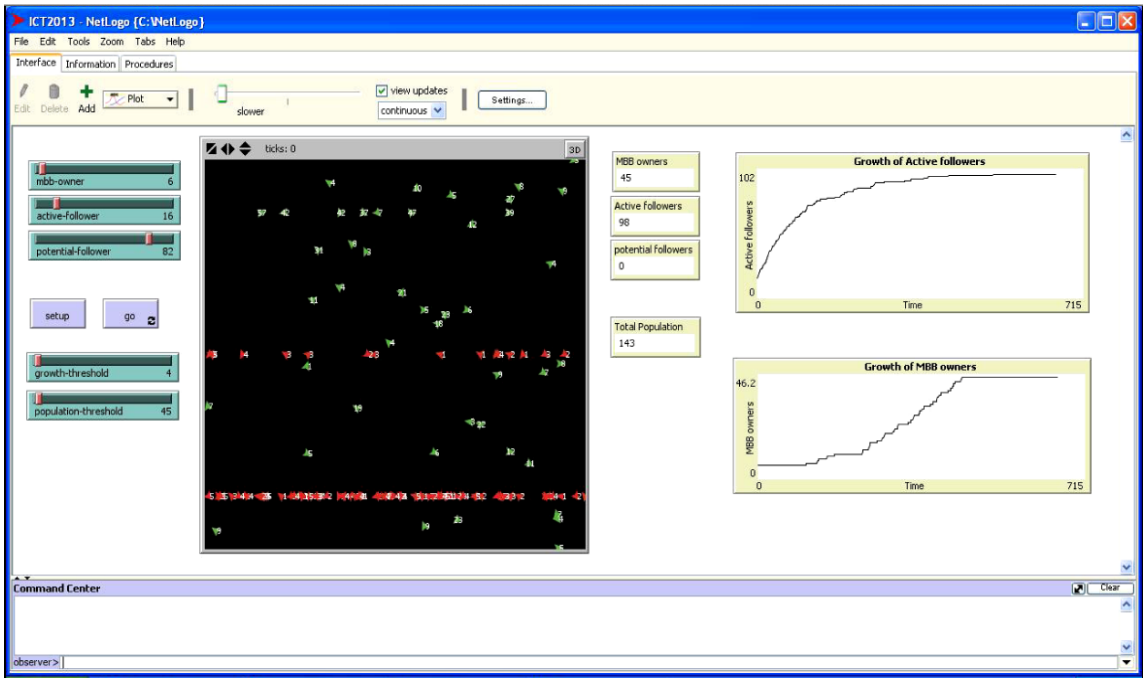
In recent years many tools have been developed for agent based modelling and simulation. For this work we made use of NetLogo 4.1 [16]. NetLogo is a programmable modelling environment for simulating natural and social phenomenon. It is particularly suitable for modelling complex systems developing over time. It consists of a programming language, a set of libraries and provides a graphical tool for constructing interfaces for running agent based models.

**Figure 1: NetLogo graphic user interface for the simulation**

## The Agents

For our simulation, we identify three categories of agents:

1. *MBB owners* – This category of agents represents an accessible mobile bulletin board that has been set up by an individual or a community.
2. *Active followers* – These are people, subscribed to any mobile phone network, with short messaging services (SMS) capabilities and who access mobile bulletin boards.




3. *Potential followers* – This category of agents represents anyone in the sample population who is not subscribed to any mobile phone network, with short messaging services (SMS) capabilities and has not yet accessed any mobile bulletin boards.

## The Simulation Cases

We identified two cases that can be simulated using our model:

1. A mobile bulletin board is accessed regularly and repeatedly by many followers: for example, a specific bulletin board such as a church bulletin that is regularly visited by many of its members, for the verses or bible passage to read for the day.
2. A specific follower X, following a particular mobile bulletin board: This board is accessed regularly and repeatedly by the same follower: X follows a specific bulletin board such as someone who regularly checks on a specific bulletin board for the verses or bible passage to read for the day.

The section below discusses the growth rate for the mobile bulletin board owners' population in each of our simulation cases.

## Simulation Results

Figure 1 above shows a screen capture of the NetLogo graphic user interface for the

simulation of our model. The graphs show the growth of active followers and the growth of the active bulletin board owners. The key features are:

1. The slide bars to the left are used to control the values of various categories of agents in our population sample.
2. The buttons to the left are used to initialise and to run the simulation.
3. The central dark area shows a 2-dimensional representation of the world of agents
4. The monitor boxes to the left display a count of the different categories of agents during the simulation.
5. The graphs to the far right show the growth rate of the active agents and the growth rate of the mobile bulletin board owners.

**Discussion**

At the start of the simulation, we initialised the number of mobile bulletin board owners to about 10% of the sample population and potential followers to about 60% of the total population. During the simulation, we monitored the rate at which mobile bulletin board owners were being created as stated in the simulation cases above.

This work opens discussions on three main aspects:

1. A mathematical model for Mobile bulletin boards
2. Agent based modelling and Simulation
3. The suitability of NetLogo as a tool for this type of studies.

At this stage of the work, our model is currently being tested and fine-tuned to get a better representation of the real world scenario.

**Conclusion and Perspectives**

Mobile bulletin boards promise a secure and accessible mechanism for information dissemination in Sub-Saharan Africa. An in depth understanding of the factor that influences its adoption is advantageous to scholars and businesses alike.

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