Modelling The Growth of 2G Mobile Services: An Agent Based Approach

D G Mansbridge & L E Sacks

Department of Electronic and Electrical Engineering

University College London

Abstract: A simple agent based model of the growth of GSM mobile subscribers using SDML (strictly declarative modelling language) is described. This model specifically addresses the role of the Short Message Service (SMS) in that growth. Significantly, the agent based approach considers some of the broader socio-economic factors that determine uptake, the complex interactions between the services under consideration and the adopters of those services. The potential implications for evaluating the likely success of the more advanced 3G services are considered.

1 Introduction.

Whilst the technical, regulatory and economic determinants (at least at the macro level) of the success of GSM are generally understood and agreed [1], the picture is incomplete unless some consideration is given the local affects of the market place, the diverse patterns of purchasing and subscription behaviour, often along distinct demographic lines based on such factors as occupation, age, disposable income hobbies, interests, fashion and potentially a whole gamut of other factors. For example, much of the retail and wholesale revenue growth in recent years has been attributed to SMS, a service that has ostensibly been adopted by the younger pre-pay generation (generation 'Y'). And although in hindsight much may be attributed to the extensive reuse of existing signalling infrastructure (CCS7 signalling channel for messaging) facilitating low operating costs and reduced service prices (relative to voice), few could have predicted the precise size, nature (demographics) and impact of the resulting SMS market. Clearly, the relationships between these 'heterogeneous agents' in the mobile market, between the services, the supporting technologies, and the users themselves, are complex.

Capturing the subtleties and complexities of the interactions between services and users by simulation (modelling) increasingly provides insights into the nature of these interactions and their outcomes. Agent based modelling (ABM) is an approach to simulating the interactions within a heterogeneous (complex) environment that has been employed to solve a broad range of problems for more than twenty years [2]. A 'model' is defined in terms of a number of component agents who may either represent individuals, or groups and organisations, and whom are characterised by autonomy, cognition (through a set of internal logical rules), adaptation (through learning), and interaction. At run-time the properties of the simulation emerge as a result of the behaviour of and interactions between the agents, rather than predefined system-level constraints. Prediction of the resulting properties is difficult or impossible, because of the characteristic non-linearity resulting from individual or 'local' agent behaviours. It is this proximity to the complexity of behaviours and outcomes in the real world that is one of the essential strengths of the approach, although processing and computational restrictions often limit the degree of realism that may be achieved [3].

Despite such limitations, the agent-based approach is an ideal fit for modelling the interactions between services (in this case the 2G services voice and SMS), operators, and users (defined by distinct demographics). The bottom-up approach to simulation, by defining the model based on the component or heterogeneous constituent agents, should more accurately reflect the complexities and subtleties of the environment in question, the mobile telephony market place. A further benefit of ABM is the potential for iteration and scaling. Assumptions may be made about agent behaviours, the simulation run and results generated. These results may be subject to verification against data from the real world by SMEs and the model updated. In this way, the simulation may evolve from a relatively 'naïve' implementation, based on a certain level of intuition and assumption, to a more faithful representation of the real world, via an ongoing process of verification and refinement.

2. The Model

The model is defined using SDML (strictly declarative modelling language), an agent based modelling tool developed by the Centre for Policy Modelling (CPM) at the Manchester Metropolitan University Business School. SDML is rule-based, that is; agents are cognitive entities with rules that define their behaviours and whose decisions depend on the outcome of the behaviours (rules) of the other agents in the model. Rules may be considered to correlate to the logic employed by individuals, groups and organisations in the real world [4, 5]. The simulation is run over a number of predefined time levels, rules typically being fired in parallel by the various agents in the model. Agents generally have access to the results of rule firing (held in a database) though not until completion of the current time iteration when the set of rules have finished firing. Other benefits offered by SDML, in line with its object-oriented structure, include encapsulation (containment), inheritance (by type or by module) and by implication, significant scope for reuse and ease of scalability of the model.

The agents defined in this model represent eight groups of consumers, each a distinct demographic within the population, defined by occupational type and average income [1], and four competing mobile operators offering voice services plus SMS. See figure 1 below.

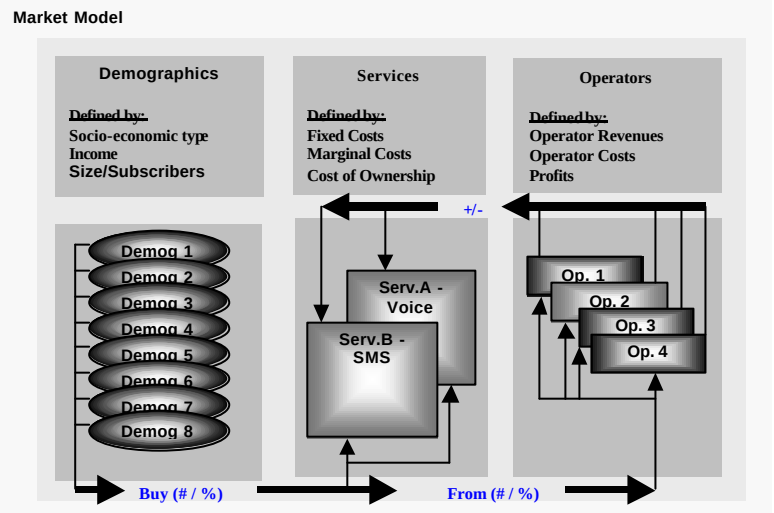

Figure 1: High level representation of the 'Voice & SMS on GSM' Model

Prices for each service are defined by cost of ownership over a fixed period, with some variation between operators, based on their fixed and marginal costs. An 'elastic market' is assumed, where operators reduce prices in order to capture the largest share of the market, whilst maintaining revenues and profits. Thus, the average cost of ownership falls steadily throughout the simulation. Demographics are characterised by their propensity or likelihood to subscribe to these services. As subscriber numbers increase, so does the 'value-addition' of buying-in to that service. Thus the growth of the number of mobile subscribers follows an exponential form, where the probabilities of new subscribers increases based on the existing subscriber numbers. This 'propensity' is not uniform, varying across demographics. For example, demographic-1 represents high-income professionals. This group has a high propensity to purchase regardless of price, due perhaps to their occupational needs and available disposable income. They may be considered the potential 'early adopters'. At the other end of the socio-economic spectrum, demographic-8 represents the unsalaried, such as the young, students, and the unemployed, whose lifestyle choices are more limited by their income.

This simple model captures an equivalent time period of just ten years. Within each year two iterations are defined, one in which buying takes place (demographics subscribe to the services and choose the operator from whom they buy) and one for accounting, in which the operators determine revenues and profits for the current year, and update prices for the subsequent year.

[1] The following demographics are defined; (1) professional (high income), (2) employers and managerial, (3) professional (low income), (4) junior non-manual, (5) skilled manual, (6) semi-skilled manual, (7) unskilled manual and (8) unsalaried.

3. Results and Analysis

Figure 2a below illustrates the rate and spread of subscriber uptake for each demographic where voice is the only service on offer throughout. During the first half of the simulation it is the highest demographics (1 to 3, managerial and professional) that are the early adopters. As prices reduce, uptake amongst the lower 'cost conscious' demographics (4 to 8) grows, and as predefined price thresholds are passed, the uptake increases by an order of magnitude, particularly amongst the lowest groups (7 & 8, unskilled and unsalaried).

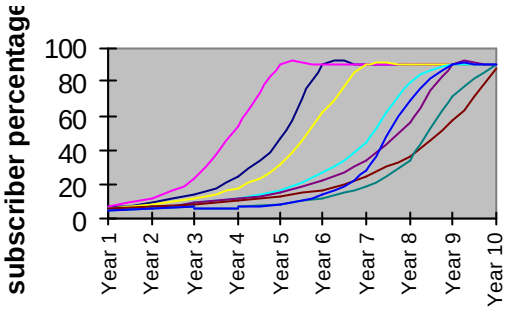

Figure 2a: Uptake (Voice Only)

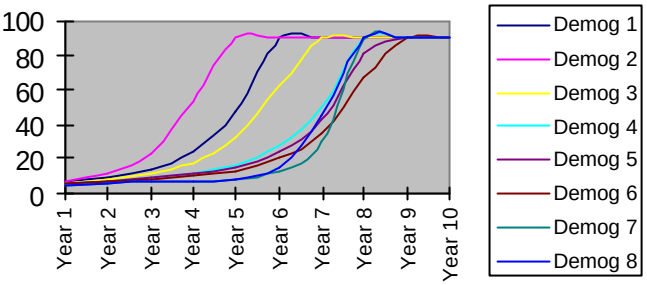

Figure 2b: Uptake (Voice & SMS)

A limit of 90% saturation of the potential market is defined. This is an arbitrary metric that can be used to compare speed of uptake (based on number of years to it takes each demographic to reach this figure), for a range of conditions and control variables. Most notably, the affects of reducing the average price on speed of uptake over each simulation, as summarised for the 'voice only' simulation in figure 3. Those cost conscious demographics (4 to 8) are influenced more by price, so consequently in each simulation as the average price is reduced, the rate of uptake increases and the number of years to saturation (90% of market) falls, the magnitude varying from group to group. As illustrated there is a point at which this trend plateaus, beyond which further reductions in average price have no affect on rate of uptake.

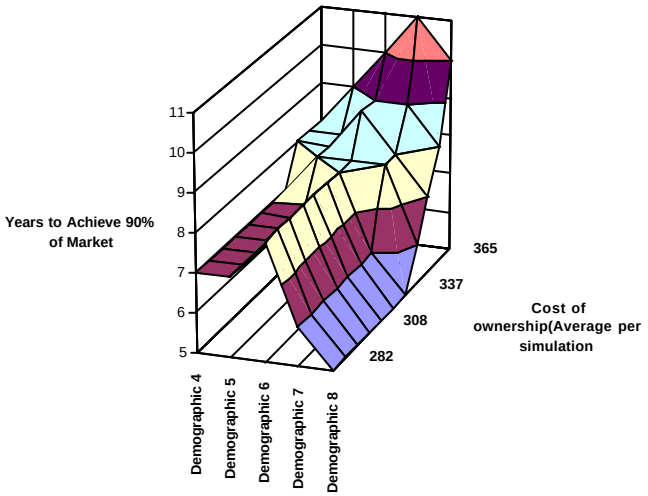

Figure3: 'Time to 90% of Market' (Voice Only)

The impact of introducing SMS into the model is illustrated in figure 2b above. The service is introduced halfway through the simulation. SMS effectively provides each group with an option for reducing the cost of ownership. This results in an increase in the number of new mobile subscribers once the service is introduced and in each of the subsequent years. Essentially this has a catalytic effect on growth amongst the more cost conscious demographics. With the addition of SMS the higher number of mobile subscribers overall increases 'value addition' for both potential voice and SMS

subscribers, the effect of which is to further increase the propensity to purchase year or year. Not only does the introduction of SMS reduce the 'time to 90%' in each case, there is an associated compression of the time difference between demographics. The net effect can be seen by comparing figures 2a and 2b on the previous page, and is summarised in figure 4 below.

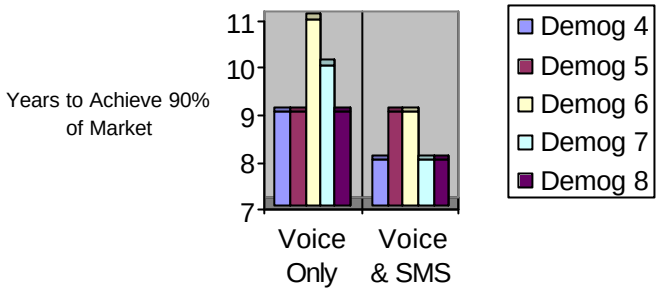

Figure 4: 'Time to 90% of Market', Voice and Voice/SMS Simulations

4.Conclusions

The intent of this model is to capture the nature of the interactions between services and users in the GSM market place. By defining some very simple agents, it has been possible to reproduce the qualitative pattern of mobile uptake and the 'catalytic' nature of the role that SMS has played in this. Following a process of verification and refinement of the agent definitions should generate results of a more precise quantitative nature, providing a more accurate representation of the real world. Arguably the agent based approach has potential application to the more complex and diverse world of 3G services, where given the broader range of services, access devices and technologies, the interactions of user behaviours and these services introduce further layers of complexity and accurate prediction of market trends and service growth becomes still harder and the scope for error somewhat greater. The use of agent based modelling may at least provide some insights into the conditions under which these services are likely to thrive.

References.

[3] The History of GSM, article on GSM World, the Internet site of the GSM Association. Available at http://www.gsmworld.com/about/history/index.shtml

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[4] SDML: A Multi-Agent Language for Organisational Modelling, by Scott Moss, Helen Gaylard, Steve Wallis and Bruce Edmonds (Computational & Mathematical Organization Theory 4:1 1998 43-69)

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Acknowledgements.

Costs and pricing used in the model are based on data drawn from the 'The Profitability and Efficiency pf the UK Mobile Network Operators' report, prepared by NERA (National Economic Research Associates) for Oftel in August 2001.

The demographics definitions used in the model are based on data drawn from the Office for National Statistics (ONS) 'Living in Britain' report on the results of the 2000/2001 General Household Survey.