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ABSTRACT

Although enthusiasm for the "killer-application" in the mobile sector has decreased, location based services still seem to be valuable mobile services. Today's location based services are mostly forced to use the proprietary location information provided by mobile network operators. The approach that is discussed here depicts a way of locating a mobile client independently from certain network operators and in heterogeneous networks. The Location Trader system collects and provides location information for users and providers of location based services. The accumulated interaction of each user of the user community enables to generate reliable location information in the Location Trader database. This paper prepares the groundwork for modeling the core principles of unintended value co-production with the Location Trader System. We intend to focus our analysis on the Location Trader System resp. Services, as the phenomenon of value co-production is widespread because of low coordination costs for integration and transactions enabled by immateriality and potential automation of business and transaction processes. The focus of this paper is the simulation of the user integration based on the theoretical basis.

Keywords: Location Aware, User Integration, Collaborative, Mobile Service

1. INTRODUCTION

Location-based services are considered by many as the next generation of mobile services with a huge potential: Allied Business Intelligence, for example, predicts that the market for location-based services will grow from one billion US dollars in 2000 to about 40 billion dollars in 2006.

Currently the development of such services, however, is severely impeded by the lack of an open, network-crossing positioning platform: Only splintered solutions are available for particular networks and the various operators of these networks are eager to defend their positioning monopoly.

In a novel approach the Location Trader system aims to overcome this situation and to establish a generic positioning platform that fosters the development of innovative and diverse location-based services.

The Location Trader approach is based on the integration of service users in the creation of the positioning service. It has first been introduced by Dornbusch and Huber in [1].

The Location Trader system constitutes a virtual link between service users, service providers and developers in a complex network constellation of these economic actors. This property together with the fact that the service is build up in cooperation with users poses several challenges for the successful launch and operation of such a system.

We identify two key properties of the Location Trader concept:

- Quality of service and therefore the value of the positioning platform increases with the number of people involved, and
- The system relies completely on volunteer contributions by its users.

In this paper we use the Location Trader system as a case study for analyzing unintended value co-production both qualitatively and quantitatively. We first introduce the relevant economic literature in section 2. In section 3 we apply these theories to the Location Trader concept. Section 4 models the concept quantitatively in a computer simulation and analyzes the results. The findings are summarized with a conclusion in section 5.

2. VALUE CO-PRODUCTION VIA USER INTEGRATION

Value co-production is different from the traditional view of value creation as a value chain [2]. Value co-production adds a new dynamic to the producer/customer relationship by engaging customers directly in the production or distribution of value [3][6]. Some researchers have given an even broader definition as "value co-creation by two or more actors, with and for each other, with and for yet other actors" [4].

Value co-production exhibits the following characteristics: Value is created more and more synchronously, it is created more interactively and it is created involving more actors. This has been enabled by recent technical breakthroughs and social innovations.

From a more implementation-oriented perspective, value co-production requires motivating customers as well as monitoring and managing the process of co-production. There are three generic ways of integrating the customer in the creation of value [5]:

- *Innovation* which describes an intended, innovative and creative contribution like generating new service ideas
- *Substitution* where a certain activity that used to be carried out by a service provider is now carried out by the customer, representing an intended but not innovative way of value creation
- *Variation* which describes a non-intended, non-creative and non-innovative contribution. "The value of a single customer activity is so small that the customer is not able to exploit his contribution and only the aggregation of many single parts by the service provider allows realizing the value" [5]

Some research has also been done on the potential of co-created value over time. For this Huber and Sandner have investigated *variation* as the special case of value co-creation where actors unintendedly and probably even unconsciously participate in value production [5]. This *non-intended value co-production* is made possible by the automation of certain business processes and the immateriality of the generated value, namely information.

A service based on variation usually exhibits feedback effects as contributions by users are aggregated over time and used to refine the service. Considering this feedback loop for the analysis of the service potential over time suggests the following three-phase model:

- Build-up of service: The initial service potential is low and will be build up over time through user input
- Stable system: User input and potential loss are balanced so that the system remains stable without the input from the service provider
- Skimming of potential: The user-created potential can be skimmed by the service provider

3. QUALITATIVE ANALYSIS OF VALUE CO-PRODUCTION WITH THE LOCATION TRADER

The economic ecosystem of the Location Trader concept involves two economic actors around the Location Trader positioning platform (see Figure 1): *Service providers*, who base their location-based services on the Location Trader positioning platform; *service users*, who access these services and contribute their current locations if necessary.

By design the Location Trader system relies on contributions by service users: They are the ones disclosing their current location when their current position – in the case of cellular networks the current network cell – is not known to the system yet. This way they contribute to building up the location data pool and – together with all others service user – co-create value for all involved parties by improving the quality of the positioning service.

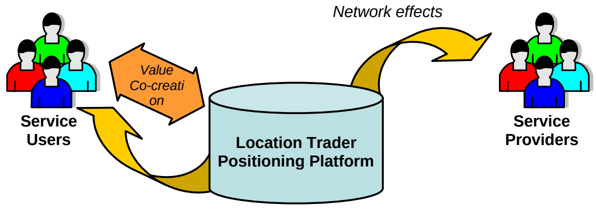

Figure 1: Economic ecosystem of the Location Trader approach

Co-creation in the case of Location Trader is enabled by cellular communications technology and the Internet in connection with the fact that the created value is immaterial information which can be transmitted and processed very cost-efficiently using these technologies.

The Location Trader approach exhibits the properties of value co-production, especially through value being created synchronously and involving all service users at the same time. This suggests modeling the value creation process as a value constellation rather than as a value chain where management has to focus on managing the interactions within this constellation.

Analyzing this value creation constellation from an implementation point of view suggests considering the following *risks*: Privacy concerns of service users may prevent them from contributing to the system. When they feed the data pool with location information they effectively disclose their current location. As they are requesting a location-based service this is actually required and will be plausible to them. However, as the system stores this information in the data pool, service users may be concerned that this information is used to track or trace back their movements. It needs to be credibly assured that the information they contribute is stored anonymously and therefore cannot be associated with their identity at any point of time.

Legal risks play a minor role in the co-creation process of Location Trader as the contribution process is well defined and the contributed information is always mere location information. However, it has to be ensured that intellectual property issues are considered.

The main *challenges* for co-creation in the context of Location Trader are goal divergence, effort and equity returns.

Both service users (as the value co-creators) and the positioning platform have different goals: Service users want to receive information or services based on their current location; the positioning platform wants users to access services and disclose their current location in order to feed the location data pool. Nevertheless both goals can be combined and jointly satisfied with the Location Trade co-creation process where contributions are only required if nobody else has made a contribution yet.

Crucial for motivating users to contribute is to minimize the effort of contribution: Contribution in the case of the Location Trader co-creation process is a very structured and invariable task that can be highly automated. As most users are naturally used to disclosing their current location when requesting a location-based service they do not even perceive an additional effort. In fact, each user's average effort is reduced as contributions do not have to be made every time, but will automatically be reused in the future. There is a greater effort on the side of the positioning service to enable the co-creation of value through service users, but this effort has to be accepted as it constitutes the core of the whole concept.
Interrelated with these two challenges is the issue of equity of returns. The return to each service user for the disclosure of their current location is the provision with a location-based service. It has to be ensured that the value of these services is perceived equitable to effort by each service user.

Applying *best practices* of value co-creation to the Location Trader concept yields the following insights:
The objective of co-creation in the case of Location Trader is clearly defined: Service users disclose their current location so that the positioning platform can associate this location with the user's current positioning in a cellular network and can reuse this information in the future for positioning services. So co-creation takes place at the production stage. It also takes place at the maintenance stage once there is sufficient data available and further contribution are just used to refined the data pool and keep it up to date.

This implies that within the Location Trader ecosystem only service users can be selected as co-creators. It may make sense to further segment this group in order to select those of them who are most likely to contribute frequently.

The different rights of the involved parties need to be considered: Service users have the right of privacy and that their contributions are not associated with their identities. The positioning platform has the right of storing and using the contributed information.

Expectations of both involved parties need to be explicitly managed: Service users should expect that they are provided with a location-based service, but may sometimes have to disclose their current location. This will be the case more and more rarely in the future. Vice versa the positioning platform can expect every user to disclose the current location when it is required.

The channel that the positioning service can use to monitor and control user contributions is the list of incoming locations. They should be checked for plausibility before they are added to the core data pool.

Service users need to be enabled to contribute by providing them with the required Location Trader Client Applications and by making the contribution process as easy and self-explanatory as possible.

The users' incentives to contribute need to be explicitly communicated and managed. There is the immediate incentive of being provided with a location-based service that otherwise would not be available. However, there are also more indirect incentives such as the idea of the Location Trader platform as an independent, open source-like data pool where contributors can identify themselves with this vision. A competitive and signaling incentive can be created by allowing the association of a particular network cell with the nickname of the user who first "discovered" and contributed the cell to the data pool. Other incentives can be thought of.

An important aspect of value co-creation in the case of Location Trader is that it takes place automatically and not necessarily intentionally: The basic co-creation process is automated and users need to be involved only if their current location is not known to the system yet. Only then they become aware that they need to submit information in order to be provided with a location-based service. However, they are not necessarily aware that this information will also be reused at a later stage and therefore they are not aware that they are actually co-creating value. This kind of integration is denoted as *variation* as it is non-intended, non-creative and non-innovative.

Theory suggests that the potential of a service with these properties will follow a pattern of three phases over time: A buildup phase where initial potential is low and increased over time through user integration. A stability phase where the service remains stable just based on user contribution. Finally a skimming phase in which the service provider can skim the co-created value.

This section has applied the theoretical basis on value co-creation as presented in the previous section to the Location Trader system. It has pointed out risks, challenges and implications based on best-practices. Finally, it presented a three-phase model of the potential of the service over time.

4. QUANTITATIVE COMPUTER SIMULATION OF VALUE CO-PRODUCTION WITH THE LOCATION TRADER

In addition to the theoretical and qualitative analysis of the Location Trader system in the previous section, this section presents a more quantitative analysis based on a computer simulation as a second approach to understanding the system's mechanics.

The simulation models the service usage behavior of a certain number of Location Trader users within a certain area and over a certain period of time. It takes into account several factors such as contribution of locations, individual satisfaction and completeness of the data pool. By varying initial settings and comparing the effects on the resulting simulations, the importance of particular factors is determined.

It is important to bear in mind that all conclusions are based on an idealized model of the real world and cannot be taken for granted. Nevertheless they can help to identify general interdependencies and trends. Furthermore the simulation should serve as an interactive model for playing around and experimenting.

4.1 Model

The model of the Location Trader system assumes a certain number of users in a certain quadratic area. This area is partitioned in equal-sized squares where each square represents an idealized network cell in a cellular network. Every user is unambiguously located within one of these network cells, however, as in real life one cell can accommodate several users.

Each user in the model has the properties requests, contributions, satisfaction and frustrations. *Requests* counts for each user how frequently the user requested a services. *Contributions* represents the number of locations that the user contributed to the data pool. *Satisfaction* measures the satisfaction of each user by incrementing the current value each time the user requested a service and was automatically provided with the service without the need of contribution. *Frustrations,* on the contrary, counts the situations when a user requested a service and had to provide the current location manually.

Each cell has the property *locations* which counts how many locations have been mapped to the cell's cell ID. If a cell is mapped to at least one location the model assumes that a service request in this cell can be satisfied.

When the simulation is started, each user acts autonomously, but everybody follows the same rules: First, the user roams around, which may or may not result in changing the network cell. Second, the user may or may not request a service which will either satisfy the user, if at least one location has already been mapped to the current cell, or will frustrate the user and cause the user to contribute the current location to the data pool. If the discrepancy between *satisfaction* (successful request of services) and *frustrations* (need to manually contribute the current location) grows too far, a user may be disappointed and stop using the system. On the other hand, if *satisfaction* exceeds *frustrations* by a certain value, the user starts using the system more frequently and may even recruit new users to the system. Finally, after all users are done, a random network cell may be removed from the data pool to simulate changes in the network infrastructure.

The environment and exact behavior of the users is determined by several initial settings and also randomized between certain boundaries.

The cellular network environment is modeled by the radius of each cell and the number of hours after which the data pool is degenerated to simulate a change in the network infrastructure. In addition, the initial number of users, who will be randomly distributed over the network, can be set.

The behavior of the users is mainly influenced by the average number of times per week that they request a service (*usage*) and by their *mobility* that influences how frequently they move to another cell. Of course, this depends also on the radius of the cells.

In addition, it can be set how many more frustrations than satisfactions a user can stand before abandoning the system (*discouragement threshold*). The *recruitment threshold* determines how many more satisfactions than frustrations a user has to experience in order to start recruiting new users. The probability of a successful recruitment can be set, too.

Finally, it can be varied how frequently the systems asks the user to contribute the current location although the data pool already contains a location for the current cell (*redundant location request*). This is to maintain the integrity of the data pool and also to increase positioning quality.

4.2 Implementation

The previously described model was implemented using the software StarLogo 2.0[1] by the Media Lab at the Massachusetts Institute of Technology (see Figure 2 for a screenshot). StarLogo is a programmable modeling environment designed to help modeling and exploring the workings of decentralized systems, such as bird flocks, traffic jams, and market economies. It is available free of charge for download.

StarLogo is an extension of the Logo programming language and adopts Logo's terminology of autonomous *turtles* living on *patches* and an *observer* observing and controlling what happens.

In the implementation turtles represent service users and patches represent networks cells. The observer controls the overall simulation flow and provides a global clock.

[1] StarLogo website: http://education.mit.edu/starlogo/

The simulation is partitioned in discrete steps where each step represents one hour of simulated time. In each step each turtle completes one sequence of roaming and then probably requesting a service.

The parameters described as the initial settings for the model are implemented as *Sliders* on the simulation area and can be adjusted by the user. Service users/turtles and network cells/patches are visualized on the so called *Graphics Canvas*. The color of the patches is scaled between black and light green where the level of green indicates the number of locations mapped to a patch. The color of the turtles is scaled between dark red and white where the brightness indicates the level of satisfaction of a turtle.

So called *Monitors* display indicative figures such as the total number of requests, users and contributed locations. Furthermore the completeness of the data pool is measured as the percentage of cells that are mapped to at least one location. A fictive value of the current data pool is calculated by valuing the first location for each patch with a value of 5, the second location with a value of 3, the third with a value of 2 and the forth with a value of 1. Finally, overall and average value for each user's contributions, satisfaction and frustrations are indicated.

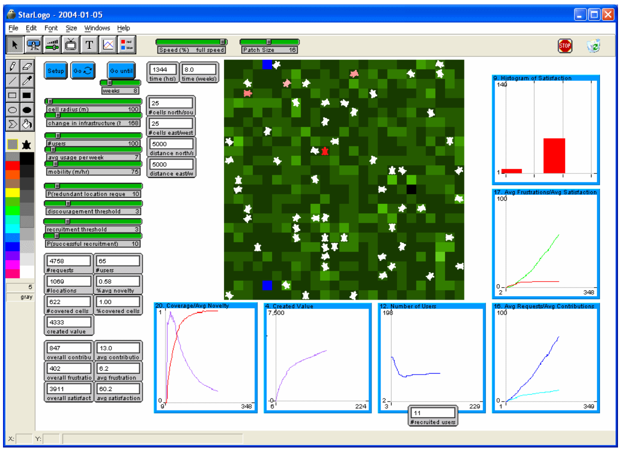

Figure 2: Computer simulation of the Location Trader concept in StarLogo

The temporal development of some of these figures is visualized in small *Graphs*. (Note that these Graphs can only use running time as their axis in x direction in contrast to simulated time.)

Three *Buttons* allow controlling the simulation: Setup resets and initializes the simulation with the current parameters. Go starts the simulations and runs it until the button is pressed again. Go until starts the simulation and runs until the simulated time has reached the predefined number of weeks.

4.3 Simulations

As a structured approach to simulation, two scenarios and a set of basic initial settings have been chosen. They serve as a basis for comparison with simulations where selected parameters have been varied.

The two scenarios are an urban and a rural scenario. The urban scenario tries to model an urban environment where there are smaller and more network cells in a certain area. Based on reported average cell sizes the cell radius has been set to 100 meters with 25 times 25 cells. The resulting area of 5 times 5 kilometers approximates the area covered by the city of Munich.

The rural scenario is modeled after a rural environment where the radius of a cell can be several kilometers. Here a cell radius of 3000 meters has been chosen and the covered area is 15 times 15 kilometers.

The following basic initial settings have been chosen: The number of users has been set to 100. This seems to be a reasonable number that should be possible to reach with a concentrated effort at the university, the CDTM community and word-of-mouth propaganda. The average usage of Location Trader-based services has been set to 7 times a week which corresponds to 1 usage per day. This is a reasonable number, especially when motivation and curiosity are still high in the beginning. The average mobility of users has been set to 75 meters per hour which means that users move at most 75 meters per hour on average. This setting takes into account that most people spend several hours a day in the same building, where only few cell changes occur, but sometimes cover longer distances, for example during lunch break or in the morning and in the evening. Finally, the system has been set to require the user to contribute the current location redundantly in 10 percent of the cases where a location has already been mapped to the cell. It is assumed that a user accepts three cases more in which the current location has to be provided manually than cases in which a service is provided automatically. And it has been estimated that a user has to have been satisfied by the system three times more than being disappointed in order to start recruiting new users.

Based on these basic initial settings several simulations have been run. A comparison of the results of simulations with the same initial settings has shown that outcomes are converging and are therefore representative for the selected initial settings.

4. 4 Evaluation

In 20 different simulation setups five basic initial settings, as explained in the previous section, have been varied along a single dimension each time in order to single out and identify their effects on the simulation outcome. Both urban and the rural scenario were considered. The simulation was run for a simulation time period of 8 weeks to allow a comprehensive overview of the launch period.

The five settings that were varied are: the initial number of users, frequency of usage, mobility of the users, the users' discouragement threshold and the redundancy of contribution (the percentage of cases in which a user is required to provide the current location although at least on location information is already available). All these settings were both halved and doubled one after the other and the effects on the simulation outcome were examined.

The examination was based on the value of nine indicative figures at the end of the simulation: the completeness of the data pool, the total created value based on the valuation as described in 0, the number of users, the total numbers of requests and contributions and the users' average number of requests, average number of contributions, average satisfaction and average frustration.

4.5 Urban Scenario

The outcomes for the urban scenario suggest the following interdependencies (see also Table 1):
Both the initial number of users and the frequency of usage seem to have the greatest effect on the completeness of the data pool. While an almost complete coverage is achieved in almost all cases after at least 8 weeks, these two factors speed up the process. They also increase the total created value and the overall number of requests and contributions. The initial number of users has an even higher impact on the latter two, whereas the frequency of usage increases the average number of requests per user. This is understandable as both factors have a direct effect on the number of locations contributed to the system and therefore have a direct impact on the quality of service and the satisfaction of users. Frequent usage further pushes average satisfaction which can be explained with the more frequent satisfaction that users experience. On the other hand, a greater initial number of users helps to extremely decrease average frustration as the disappointment of having to provide the current location manually is spread across more people.

In fact, the initial number of users is mission critical as in all simulations for the urban scenario a great loss of users occurs in the beginning. If the initial number of users is too low (less than 75 in the simulation) the initial great loss may even be unrecoverable and the system may fail completely. (The user loss is due to the frequent frustrations that user experience with a not-yet-complete data pool in the beginning.) On the other hand, the higher the initial number of users is, the more users the system will have in the future. In fact, this seems to be a super-proportional relation.

Surprisingly, user mobility as an indicator for the spatial distribution of service usage has very little effect on any of the indicative figures. It seems that a high number of users already provides sufficient spatial distribution.

The discouragement threshold proves to be another mission critical factor. Simulations show that users must accept at least two frustrations more than satisfactions before abandoning the system to keep the system running. Otherwise the number of users drops dramatically and the system fails. In the simulation a discouragement threshold of three is sufficient. A higher threshold has only a moderate positive effect on the number of users and requests.

Requiring the user to redundantly provide the current location has an interesting effect on several factors. Of course, it increases the average number of contributions per user and maintains the quality of the data pool. On the other hand it decreases average satisfaction and therefore the number of users. But this is only true for redundancy rates of more than 20% in the simulation. Below this value these negative effects are negligible, but improvements in completeness and quality of the data pool are still gained. A moderate rate of redundancy does therefore make sense.

In conclusion in the urban scenario the initial number of users and frequency of usage are the most effective levers on the number of service requests and the future number of users. The initial number of users is mission critical, but at the same time most effective for increasing the number of users. There needs to be a certain level of resistance of users against frustrations in the beginning. Redundant manual contributions seem to be acceptable to users within certain boundaries.

4.6 Comparison to Rural Scenario

The basic observations for the urban scenario proved to be true for the rural scenario, too. However, there are some important differences that will be pointed out in the following.

First of all, simulations for the rural scenario never failed: Initial number of users and their discouragement threshold are not as mission critical as in the urban environment. In fact, in the rural scenario there is basically no loss of users in the beginning, which is very much in contrast to the urban scenario. On the other hand, a high initial number of users does not have a significant impact on the number of users in the future. This can be explained with the fact that users in the rural scenario only infrequently change network cells due to the size of the cells. This prevents them from frequent frustrations by the system, but at the same time does not make them enthusiastic enough to attract new users. In addition, it generally slows down the build-up and completion of the data pool.

Table 1: Simulation outcomes for the urban scenario

Effect of higher … on …	Number of users	Frequency of usage	Mobility of users	Discour. Thresh.	Redund. of contrib.
Completeness of data pool	propor-tional	super-prop.	insignif-cant	insignif-cant	insignif-cant
Created value	sub-prop.	sub-prop.	insignif-cant	insignif-cant	insignif-cant
Number of users	super-prop.	sub-prop.	insignif-cant	sub-prop.	insignif-cant
Total number requests	super-prop.	propor-tional	insignif-cant	sub-prop.	insignif-cant
Total contributions	super-prop.	propor-tional	insignif-cant	sub-prop.	insignif-cant
Average requests	insignif-cant	propor-tional	insignif-cant	insignif-cant	insignif-cant
Average contributions	insignif-cant	sub-prop.	insignif-cant	insignif-cant	propor-tional
Average satisfaction	insignif-cant	super-prop.	insignif-cant	insignif-cant	insignif-cant
Average frustration	invers Prop.	insignif-cant	insignif-cant	insignif-cant	insignif-cant

As users usually stay close to their home cell, the system does not require a comprehensive data pool to provide them with satisfying services. This decreases the importance of the discouragement threshold in the rural scenario. The negative effects of requiring redundant contribution are also reduced. However, due to the size of network cells in the rural scenario, positioning accuracy in general is dramatically lower which affects the overall value of services to users.

All in all, general trends and interdependencies are the same for both the urban and rural scenario. However, the rural scenario is less prone to failure, but at the same time provides lower quality of service due to lower positioning accuracy.

5. CONCLUSION

Value co-creation takes place between service users and the positioning platform. The major risk involved with this is that privacy concerns of service users may prevent them from contributing to the system. It has therefore to be credibly assured that the location information cannot be associated with their identity at any point of time. The Location Trader approach naturally ensures that the goals of both parties are satisfied in the co-creation process: the positioning platform improves its data pool and service users are provided with a location-based service. Requiring a contribution only if necessary further reduces the effort of co-creation. In order to ensure equity of returns, the quality of the offered services has to be guaranteed. For encouraging service users to contribute their expectations have to be managed and they have to understand why they sometimes have to disclose their location. A major incentive will be to fascinate them for and make them identify themselves with this independent and open source-like approach. Still, contributions have to be checked for intentionally corrupt information. Finally, as the co-creation process is nearly completely automated, some users may not even perceive it as such.

For quantitative analysis the service usage behavior of a certain number of Location Trader users within a certain area and over a certain period of time was modeled in an idealized computer simulation.

The model takes into account environmental factors such as network cell size and initial number of users as well as individual factors such as frequency of usage, number of requests, number of contributions, each user's satisfaction level, frustration level and tolerance towards frustration before abandoning the system.

By systematically varying certain initial settings, their effect on the outcome of the simulation can be observed. Each simulation was run for both an urban and a rural scenario.

The basic observations are the same for both scenarios: Initial number of users and frequency of usage have the greatest effect on build-up speed and the future number of users. Users have to tolerate a certain number of frustrations in the beginning when required to manually provide their location. However, a certain level of redundancy in requiring contribution is acceptable. In contrast to the rural scenario, the urban scenario may fail if the initial number of users or their tolerance towards frustration is too low. However, positioning accuracy is significantly lower in the rural scenario due to the greater size of network cells.

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