

EFFICIENT AND UBIQUITOUS RESOURCE ALLOCATION - CAN SMARTPHONES IMPROVE URBAN TRAFFIC FLOW ASSOCIATED WITH NUMEROUS CARS SEARCHING FOR PARKING SPACES?

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1. INTRODUCTION

A single parking space requires an area of approximately 10m². The total number of parking spaces in an urban area therefore has a relatively great demand for land, as opposed to other buildings (Grundtner, 1988). Thus every parking space competes with other beneficiary claims within the limited city space (Aebischer, 2004; Regierungsrat Kanton Basel-Stadt, 2011) and generates further external effects such as noise, exhaust emissions, etc. (Maibach, Iten & Mauch, 1992; Waterson, Hounsell & Chatterjee, 2001). These factors demonstrate why Aebischer states that the optimal planning of parking space becomes the most important control parameter for a city's traffic density (2004). To approach the problem and create more parking facilities, a more efficient allocation is needed. According to Arnott and Inci (2006) the best solution would be to keep raising parking fees until there is no more search traffic, i.e. traffic arising due to cars searching for parking spaces. The second best solution would be to offer sufficient parking space. However, this is infeasible due to the limited space in a city.

Hence, parking space management is essential for a city. Research thus far in the field of parking space management has been mostly focused on single parking systems and their technical architecture (Caicedo et al., 2012; Chou, Lin & Li, 2008; Idna & Tamil, 2007; Kumar & Siddarth, 2010; Kurauchi, 2008; Wang & He, 2011; Waterson et al., 2001) or on regional planning concepts (Aebischer, 2004; Bruns et al., 2002; Oswald, 2012). Analysis on parking space management by means of smartphones is limited to the development of prototypes of applications (Zeng, n.d.). Meanwhile renting of private parking space via mobile apps, or rather the sharing economy in general, represents a new trend (Rothenberger, 2013).

The aim of this study is to find out the potential of mobile applications to distribute existing resources more efficiently and to identify what they can contribute to reach this aim. The following research questions will be examined:

- *Which demands for an optimal parking space allocation are currently insufficiently fulfilled?*
- *Can these missing demands be reconciled by means of mobile applications (e.g. smartphones)?*
- *How should a system be designed to improve parking space allocation in the future?*

Firstly, requirements for the parking space allocation, that are currently not fulfilled, are identified. This is achieved by analyzing causes of search traffic and the hitherto available solution to the problem. With the U-Constructs by Junglas and Watson (2006) a theory about the ubiquitous access to information is applied to the parking space situation. Then, the theoretical statements are reviewed in practice with a comparative research study. This leads to the deduction as to what extent smartphones can fulfill the requirements. Furthermore, treatment guidelines for answering the third research question are to be determined through the case study comparison.

2. THEORETICAL BASICS

Below the hitherto existing approaches will be discussed in detail. Political ramifications are disregarded; only technical and conceptional solutions are depicted.

2.1. Causes of Search Traffic

70% of Swiss households own at least one car (Bundesamt für Statistik [BfS], 2012). Given that 95% of its life is spent parked (Shoup, 2005a), use of parking space and parking space design is one of the crucial components of mobility. According to ECOPLAN (1992) and Shoup (2005a), search traffic accounts for 30 to 40 percent of a city's traffic volume. A decline in the need for parking is not to be expected (Arnott & Inci, 2006; Maibach et al., 1992).

It is problematic that both private parking spaces and publicly available parking facilities are not “overly used to capacity [and] dual use (e.g. commuter during the day, resident overnight) of private parking place ... [is] rare. Most of the parking garages of commercial centers are closed and empty at night” (Regierungsrat Kanton Basel-Stadt, 2011, p. 7/Translation).

By contrast, parking spaces in publicly accessible areas – particularly in the city center and highly frequented neighborhoods – are overloaded. Oswald (2012) confirms that the high demand for parking space is at its peak in the center of a city and declines towards suburban areas. This effect leads to search traffic in city centers which then leads to higher external effects such as noise, exhaust fumes and congested streets. Furthermore, a lot of time is devoted to finding an unoccupied parking space (possibly free of charge), which indirectly leads to higher economic costs (Shoup, 2005, Bruns et al., 2002). As long as parking meters are not efficiently priced (i.e. priced too low) and free parking spaces are offered along the street, drivers are more likely to choose the cheaper alternative and consequently increase search traffic additionally (Arnott & Inci, 2006). Moreover, measures for parking space management can only succeed if public as well as private parking spaces are included in the concept. Otherwise a further alternative is created (Grundtner, 1988; Oswald, 2012).

Due to the high emergence of search traffic for the purpose of finding a parking space, it has to be assumed that there is no complete information on the number and position of the currently free parking spaces available. I.e. there is an information asymmetry between the parking-seeker and the parking space provider:

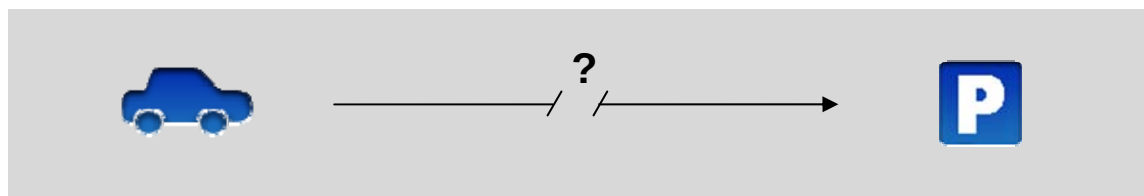


Fig. 2-1: Information asymmetry in the current search of a parking space (compiled by the author).

2.2. Existing Allocation of the Parking Resource

Generally the following types of parking space management are distinguished (cf. Haas, 1994; Oswald, 2012; Shoup, 2005):

- The basic parking space offering and its areal distribution. The parking area is offered for free and thus not further cultivated.
- The use is temporally limited, which increases the sales rate (Bruns et al., 2002).
- Management via parking charge, e.g. through a parking meter, for which a certain sum has to be paid for a defined period of time.

- Preference for particular user groups (e.g. residents, delivery men, etc.). This type will not be further addressed, given that it does not allow for an efficient classification, since the willingness to pay is falsified (Bruns et al., 2002).

Regulation via a parking charge additionally increases the influence on the parking time: By elevating the parking charge the parking time decreases and the sales rate rises (Schneider, Bäumlér & Seeholzer, 2008). By differentiation of fees the allocation can be further optimized (ibid.). Through the time-variable parking tax a different user fee for various types of use (commuter, buyer, etc.) can be demanded (Oswald, 2012; Schneider et al., 2008).

The problem with this solution is that it can only be controlled statistically. Time-variable prices are gathered (Bruns et al., 2002), but it is difficult to dynamically adjust these settings to local happenings, e.g. big events. For this regulation to be more efficient, a system would thus have to be able to react as promptly as possible to changes in the demand for parking spaces. However, there are also inconveniences with parking meters and similar devices: A physical contact with the respective apparatus is necessary to settle the bill (Idris, Leng, Tarmil, Noor & Razak, 2009). Furthermore, a suitable amount of coins for the desired parking time has to be inserted, which is not user-friendly.

Parking information systems that allow for reservation and payment via web portal do not solve the problem of the ubiquitous information availability, since the reservation has to be made before the start of the drive and it cannot be accessed during the drive. Additionally, there is no location assistance, which would be essential for guidance to the next parking space (cf. Fiechter, 2013).

The following problem areas can be derived from the findings addressed above:

- For parking space management, there is a location-dependent as well as a time-dependent constituent.
- The search for a parking space is an urgent need, i.e. short term time-dependent, which supports the demand for a wide-spread availability.
- The payment mechanisms seem to not be comfortable with the hitherto introduced systems and cannot be solved in real-time.
- For the payment function and locating function a clear identification of person and position is necessary.

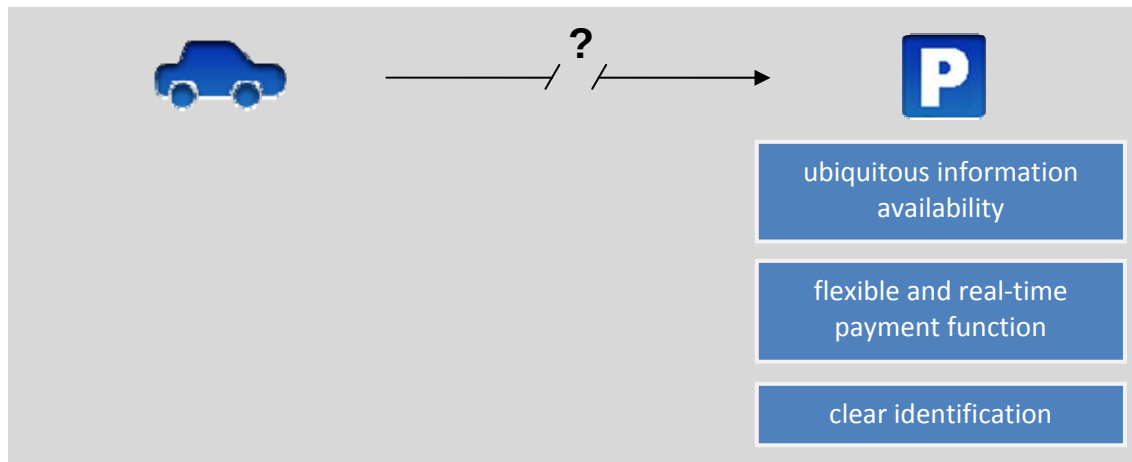


Fig. 2-2: New requirements for the allocation of parking space (compiled by the author).

2.3. Mobile Allocation

The hitherto allocation has been carried out mainly in a static way, as the previous chapter has shown. This contradicts the requirements for a ubiquitous availability of information. One theory that makes a statement to ubiquitous use and identification is that of the U-Constructs. Junglas and Watson (2006) deduced four information drives (the so-called U-Constructs) on the basis of the term U-Commerce, coined by Watson, Pitt, Berthon & Zinkhan (2002) and further developed the initial work of Watson et al. (2002). Richard T. Watson, Boudreau, Chen & Sepúlveda (2011) describe the information drives as further-reaching information needs that are at the bottom of simplicity and utility. Literature research (cf. Fiechter, 2012) further showed that a better fulfillment of the U-Constructs leads to stronger and more sustainable solutions.

In the following, the U-Constructs are briefly explained:

Ubiquity: The understanding that the access to and the accessibility of networks is available at any time from any place (portability).

Uniqueness: Allows for the clear identification of an individual or an object on the basis of characteristics and position (localization and portability).

Unison: Is supposed to raise the data integrity so that all users have access to the same information (e.g. a synchronized calendar for several users).

Universality: The universal access to all (hitherto) fragmented systems, i.e. the establishment of standards as well as the multi-functionality of devices.

The U-Constructs (symbolically depicted as a cell phone) bridge – as stated in the hypothesis of this paper – the currently missing features of the parking space allocation:

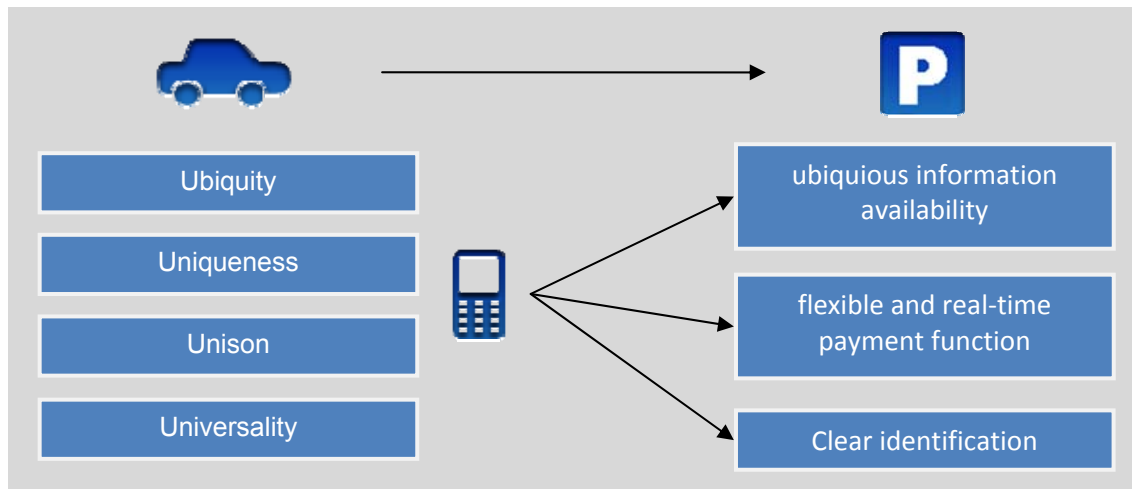


Fig. 2-3: U-Constructs allow for the fulfillment of the requirements of an optimally parking space allocation (compiled by the author).

3. METHOD AND DATA

As a research design the case study research according to Yin (2009) is chosen. The chosen case studies are examined for their fulfillment of the four information drives using a comparative case study. The following rating system is used:

Ubiquity (3 points)	To what extent is there constant (ubiquitous) access with this product? Can the product and the parking space information be accessed from anywhere? Can the product be carried along?
Uniqueness (4 points)	To what extent does the product enable a clear identification of the user? Is there a payment feature for this identification? Does the payment feature allow a flexible adaption of the prices? How is the product localized?
Unison (2 points)	To what extent does the product enable mobile access to a standardized data basis? Does the product show all free parking spaces?
Universality (2 points)	Does the product solve the problem of the fragmented systems? Is access to all functions and data guaranteed, no matter which device is used (car, smartphone, etc.)?

Table 3-1: Rating system of the case study (compiled by the author).

To compare the customer process, a standard process for the search of a parking space is defined. The process is derived from Shoup (2007) and depicts the process without parking space management systems. This is to examine whether an improvement of the previous process is achieved; in particular whether the search traffic can be avoided.

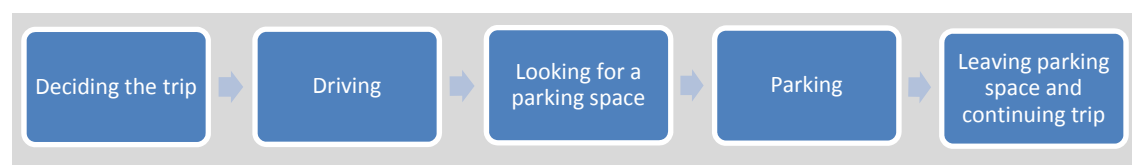


Fig. 3-1: Standard process for the search and use of a parking spot (compiled by the author, inspired by Shoup, 2007).

The following approaches for commercial parking space management have been identified based on the types of parking space management shown in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**:

- Parking meter system
- Parking ticket machine in conjunction with a parking garage which is equipped with a parking and information guidance system.
- Paying of the parking charge via text message as an example of a smart-payment-system.
- Reservation and payment for the parking space in advance through an internet platform as an example of an e-parking-application.
- Reservation and payment for the parking space through a mobile application as an example of a combination of smart-payment and e-parking.

This list corresponds to the hitherto existing development of the parking space management systems. It serves to show extremes (from not mobile and ubiquitous useable to mobile applications) as advocated by Eisenhardt (1989). Based on research of the aforementioned park systems precise products are identified. A Swiss solution is preferred to other solutions¹:

- Parking meter system TOM2008 of Taxomex (CH)
- Parking garage Elisabethen of the Basel Car-park routing system (CH)
- sweb.Reserve of SKIDATA (AT)
- sms&park of Horisen AG (CH)
- parku (CH)

Since the paper and case study at hand deals in particular with the products of the corporations and therefore solely analyzes information that is publicly available, interviews and intra-corporate documents will not be included. Only facts that are visible and observable for the product's user are relevant for the case study, since other, additional information cannot be used by him or her. In this respect this work is based on primary literature (documents of the products on the companies' websites), secondary literature (press articles and existing analyses if available) as well as observations on the use of applications by the author. These observations particularly concern the customer process and the information drives.

4. RESULTS

All case studies have in common the fact that they serve the management of parking spaces and are supposed to enable a more efficient search for a parking lot, though they differ in their approach. An extreme example is the parking meter which is aimed at raising the turn-over and thus raising the availability of parking spaces and parku which is aimed at making parking space available which had not been previously accessible.

In general, all providers and products collect data on the occupied parking spaces, though for different reasons: For TOM2008 and sms&park the focus of the control lies on whether a parking space is used and paid for. The parking garage Elisabethen is part of the Permanent Car-Park routing system of Basel, therefore its occupancy figures are used for traffic control and are publicly available. This is also due to the fact that the canton is the carrier of the parking garages and is interested in having as little search traffic as possible. sweb.Reserve follows the same principle: data is gathered and made available to reserve a free parking spot. However, the collected data is only accessible to their direct customers. The parking operators that use the sweb.Reserve system thus decided themselves who they share the data with. Parku on the contrary aims at preventing search traffic by making as much parking space data publicly available as possible. Yet Parku does not own their own parking spaces, but rather is dependent on the participation of as many private parking space owners as possible.

Below is an overview of the results of the different case studies:

Case study	Customer process	Ubiquity	Uniqueness	Unison	Universality
TOM-2008	Search still necessary	Access only possible when directly in front of it. Occupancy information is only accessible directly via parking meter	No identity function. Price adaption only directly at the parking meter. No localization possible.	Access to data base not possible; available parking spaces are not depicted.	Only serves the raising of the turn-over rate. Access only at the stationary parking meter.
Parking garage Elisabethen	Searching for a parking space can be avoided due to particular parking area.	Access to occupancy information via RSS feed.	Identification given by access card, but no localization possible.	Access to data basis via RSS feed and internet portal, but only data from the same provider.	Cross-system access not possible, e.g. access by smart phone not possible. Information is available only limited en route (information board).

sms&park	Search still necessary	Text message function always available. Access to data base not possible by mobile.	Identification and payment function via mobile phone. Prices can be flexibly adapted by text message, in contrary to the labeling on-site.	Access to data base not possible for users.	Cross-system access not possible.
web.Reserve	Search not necessary anymore, since parking space is reserved before trip.	Access via internet portal, but only before trip.	Identification through login, license plate or credit card, thereby also direct payment function. Flexible adaption of prices possible since all data is digital. Localization not possible.	Access via internet portal, particular parking space can be chosen and reserved. Only data of the same provider available.	Cross-system access not possible, information en route (via smart phone) not accessible.
parku	Search not necessary, since thanks to the localization, parking spaces nearby can be allocated.	Constantly accessible via mobile application.	Identity function und localization via smart phone, payment function via deposited credit card. Prices flexible and adaptable for each parking space.	Access to data base via mobile application. However, only shows the registered parking spaces.	Cross-system access not possible. Use of smart phone prohibited in cars and therefore not user-friendly.

Table 4-1: Comparison of the case-studies (compiled by the author).

For a more detailed analysis of the individual case studies see Fiechter (2012).

The fact that the products handle the gathered data differently is, first and foremost, linked to the precise purpose and the aim of the products. E.g. the parking meter TOM2008 (as well as sms&park, which can be seen as a mobile extension thereof) merely serves the limitation of time and the raising of the turn-over rate per parking spot. Thus the two mentioned products do not prevent search traffic, in contrast to the other applications analyzed in this paper.

According to Eisenhardt (1989), a cross-case analysis is used to identify patterns in order to recognize correlations. To identify a pattern in the degree of fulfillment of the U-Constructs, the percentile fulfillment is listed in Table 4-2²:

Case study	Ubiquity max. 3 points	Uniqueness max. 4 points	Unison max. 2 points	Universality max. 2 points
TOM2008				
Parking garage Elisabethen				
Season ticket				
sms&park				
sweb.Reserve				
Park Circa				

Table 4-2: The degree of fulfillment of the respective information drive (compiled by the author).

In the following, each information drive is analyzed and examined for patterns.

UBIQUITY

The degree of fulfillment of Ubiquity is better for the solutions that place a greater emphasis on cell phones or smartphones. These devices enable their use anytime, anywhere. Both sms&park and parku rely on the use of mobile devices (mobile phones and smartphones). The incomplete fulfillment of sms&park is due to missing functions other than the cell phone, since the product only supports the payment. The solution for parku which is based on a smart phone fulfills the information drive Ubiquity completely. The parking garage Elisabethen and swweb.Reserver achieve a partial fulfillment, given that they enable access to the information via internet portal (virtualization technology).

UNIQUENESS

At first sight the information drive Uniqueness has the highest degree of fulfillment in all case studies (with the exception of TOM2008). However, this is relativized when the fulfillment is inspected more closely: Only parku offers

an effective localization through the GPS module of the smartphone. However, for an efficient search for a parking space, the localization of the current position is necessary.

Likewise, smartphones unite the identification function better and enable mobile payment, i.e. the user does not have to locate the parking meter anymore. The demand for a flexible and dynamically adaptable price setting requires dynamic displays. The parking meter TOM2008 and thus sms&park cannot offer this. Neither can the parking garage Elisabethen, since its prices are set by the cantonal government thus are subject to a political process. The other solutions, which are fundamentally based on virtualization technologies (internet portal) and only display the prices digitally can in fact achieve price changes dynamically. This explains the improvement of the fulfillment for sweb.Reserve and parku. Therefore a solution that is based on a smartphone and a virtualization technology is superior to other solutions in the field of Uniqueness.

UNISON

The information device Unison, which is only partially achieved, is linked up with the insular systems. Indeed the currently free parking spaces are visible for the parking garage Elisabethen, sweb.Reserve and parku, but only those for the respective providers. TOM2008 and sms&park maintain an overview over the occupied parking spaces as well. However, its only purpose is surveillance and it is not accessible for the product's users. A complete data base, which would be necessary for bridging the information asymmetry, is not provided. Ultimately this is not due to the device on which the product is used, but due to the providers who do not make the information available externally. A solution based on smartphones is thus not necessarily superior in this realm; it rather depends on the provider's business model.

UNIVERSALITY

Further it is striking that Universality categorically is not fulfilled. This can be explained by the fact that the products are offered as closed systems and are optimized for a certain device. This information drive however also makes the highest demands when it comes to the realization. Again the provider's business model plays a role: The overcoming of the fragmentation requires the making of standards or interfaces to be able to access the data (of other providers) and to be able to use those on different devices.

5. DISCUSSION

5.1 Limitations of this Study

This paper lay its focus on exemplary cases of currently operated parking space management. Mostly technical aspects were analyzed. As mentioned before, the providers' business models were not studied, i.e. this work cannot show to what extent it is in the interest of the provider's business model to aim at fulfilling the U-Constructs. Furthermore, political parameters, such as the resident privilege, were neglected since they do not serve an efficient allocation. However, politically, such acknowledgments have to be made, since otherwise a parking space regiment would not find supporters in a city. Furthermore, road-pricing was not taken into account in this study. This measure would also help decrease traffic in city centers, though it is not given consideration everywhere due to political opposition (Markoff, 2008).

Moreover, the choice of the case studies was restricted to products from Switzerland, or elsewhere in Europe. Hence developments and products from other countries were not considered in this work. Additionally, only systems that are already in practice were examined.

5.2 Conclusion

This paper has shown that in the allocation of parking spaces certain requirements are fulfilled insufficiently. Through the U-Constructs it was shown that solutions which are based on smartphones are superior to other solutions in the field of Ubiquity and Uniqueness. However, the missing requirements can only be bridged partially by smartphones, particularly since the informational asymmetry poses the biggest problem. To overcome this, the information drive Unison is crucial. But this is influenced through the business concept of the provider rather than through the access channel. Consequently it can be concluded that mobile applications can improve the parking space allocation in the field of Ubiquity and Uniqueness. However, for the information device Unison an intermediary that aggregates different parking space information from the various providers and places those at the disposal of a third party is necessary. In addition, standards in the area of data interfaces are required. This establishes the basis for the overcoming of the fragmentation of the devices (Universality) by allocating applications over several channels of distribution.

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NOTES

¹ For further information and assortment of possible case-studies see Fiechter (2012), appendix B.

² For a detailed analysis of the cross-pattern analysis see Fiechter (2012), appendix C.