

Intensive shared-parking: optimising metropolitan areas space

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ABSTRACT

1. Objective

One of the main problems in metropolitan areas is to supply enough parking slots for those citizens who choose to commute in their private cars. This space must be obtained without breaking the equilibrium of land assigned to each urban use (pedestrians, public transit, bicycles, etc.) and trying to minimise the costs of needed actions.

An innovative solution to this problem for urban zones with mixed uses of land is presented in this paper. This solution entails improving the use of off-street private parking lots already existing in residential buildings, theatres, cinemas, etc. In general, these parking lots have a great amount of vacant slots in peak hours of other uses (as offices or shops), and the better use of them would lead to a more sustainable parking policy in the urban areas.

2. Data/Methodology

The paper reviews the shared-parking strategies that are used nowadays, and proposes a new intensive way of shared-parking, improving the use of the off-street private parking lots of residential buildings and buildings with other uses.

The parking slots of off-street private parking lots of residential buildings, theatres, cinemas and entertainment buildings, already existing in mature cities, are underused in peak hours of the rest of activities. Consequently, in city zones with mixed uses of land, if these parking slots were available for citizens who use their private cars for travelling to work, shopping, etc., this would be a very suitable solution to the explained problem, with an improved use of already existing resources, which lead to a higher sustainability of the system as a whole. (Although, of course, a more sustainable solution would be to transfer more trips from private car to transit).

This solution can enhance the use of more environmentally friendly modes. For example, a large parking lot between the street and the door of a building can lead to an unpleasant walking experience, while providing off-street parking slots in nearby buildings, with clearly defined walkways, separated from cars, can encourage pedestrians (Stein *et al.*).

3. Results/Findings

The paper is a reflection about how this new intensive shared parking system could be implanted and managed. As it is a new idea in a previous stage of development, no practical cases will be studied, but the philosophy of the system will be explained.

4. Implications for Research/Policy

The paper will state a new line of research about shared-parking, and can be the inception of this new line of thought about the optimization of parking infrastructures already existing in the metropolitan areas.

PAPER

1. Introduction

One of the main problems in metropolitan areas of most cities is to supply enough parking lots in zones where land is usually expensive and there is a massive influx of private vehicles.

One more sustainable solution to this problem is to get a modal change in private car users, in such a way that they move into the use of public transit systems. But no matter how much effort is made in this direction, there will always be a percentage of travellers who will continue moving in their own private cars. So, solutions must be found for getting the necessary space for parking them, trying to minimise the impact on city landscape, as well as the costs of needed actions.

Nevertheless, urban land is limited and expensive, and there is an increasingly strong tendency to recover this space for environmentally friendly modes, as pedestrians, bicycles and public transit systems, reducing the land percentage assigned to private cars (both their movement and their parking).

Considering this situation, many metropolitan areas have opted to build public off-street parking lots (most of them underground), which make room for private cars, but avoid surface land occupation in city streets. This solution has important drawbacks that will be mentioned later.

In many cases, this lack of available parking slots exists side by side with a great number of underutilised parking lots in residential buildings, theatres, cinemas, etc., during office hours.

A new approach to this problem is presented in this paper, based on optimisation, by intensive shared-parking, of the use of private parking lots of residential buildings, theatres, cinemas, commercial or entertainment centres, etc., existing in the city centre or in any other city zone with mixed uses of land.

Economic management of small parking lots, before unfeasible, is possible now by using current technological advances and improving parking management systems. This can be achieved through electronic communication systems, combined with large-scale standardisation of systems, which give rise to an economic and flexible parking lot management system, usable in many types of underutilized parking lots.

2. Shared-parking initiatives existing nowadays

Shared-parking can be defined as parking areas or spaces that are used to serve two or more individual land-uses (Stein *et al.*). The concept of shared-parking in a broad sense exists in our society almost since the spread of private car use.

Indeed, the most basic system of shared-parking is on-street parking on commercial or business streets, existing for several decades. In general, parking slots in these streets are very coveted, and usually they are managed for maximum turnover to serve short stops. Commonly, parking time is limited, and the user has to pay some short-term fees for parking. People use a parking slot and perform several actions on foot (going to different stores, making transactions in different banks, etc.). Therefore, a parking slot is being shared for different uses.

In addition to this traditional system of shared-parking, there are two other more sophisticated ways:

- Agreement between adjacent uses: in the case of two different activities that are in adjacent spaces, with dissimilar peak hours, a contractual agreement between the owners can be established for sharing the same parking lot. An example would be the case of a theatre or a hotel adjacent to an office building. It could also be the case of activities with peaks of use in different seasons, as an outdoor swimming-pool and a school.

In this case, shared-parking approach would consist on providing the set of the two buildings with a smaller number of parking slots than the one which would result of the

sum of the parking slots set as necessary by ordinances for each building, in function of the type of activity they are intended for. In this way, peak hours (or seasons) of one activity would be compensated with off-peak hours of the other. This would be done when the two buildings are going to be constructed in a given urban development, or when one of them is going to be constructed and the other one already exists.

Obviously, in this case the parking lot must be accessible within acceptable walking distances from both access points of the two buildings. In addition, the quality of pedestrian accesses must be good, and they must be convenient, safe and properly signalised and lighted.

- Parking management districts: in this case, every use of the district will have access to parking slots at any time. The greater existence of mixed uses of land with different peak hours in the district, the higher the decrease in number of parking slots can be in relation to the sum of necessities of each activity independently.

In this approach, when a new urban zone is being developed, a certain quantity of parking slots will be provided which will serve the entire district, rather than provide independent private off-street parking lots in each residential or office building, additional on-street parking, etc. The district itself is responsible for maintenance, safety, security, taxes and so forth of the whole set of parking lots in the district.

In this case each property is levied a fee, based on the property, which is used to support the functions of the district. Fee collection can be facilitated by the local government, by being included as a separate line item on property tax bills (Capitol Region Council of Governments, 2002).

If a parking management district is established, rules must be set to state necessary actions in case of modification of district parking needs, such as the expansion of the district, changes in suitability for building, change of use of a certain area, etc.

3. New proposed approach of shared-parking

3.1. Limitations of shared-parking approaches existing nowadays

As can be seen from the exposition above, shared-parking approaches existing nowadays have major limitations.

On-street shared-parking has the disadvantage that the number of parking slots available in surface is usually not enough to meet the demand for parking today. This is due to the shortage of urban land, which makes it too valuable to use the vast extensions that would be necessary to accommodate enough number of vehicles parked in the streets. This has often led to the construction of public off-street parking lots (most of them underground), with the drawback of the usually high cost of any construction and operation of car parks in the basement of a consolidated metropolitan area. This fact leads to a fairly high hourly cost of parking slots, with a deterrent effect over potential users, who will sometimes circle around congested urban blocks in search of a space and will bypass commercial garages that do have space but for which the driver must pay a high fare. Studies show that on average, 30% of traffic in dense urban areas can be attributed to such circling (US Department of Transportation, 2009).

In turn, agreement between adjacent uses resolves the problem in some particular locations, but it fails to get a general solution to the problem caused by the need of parking slots. On the other hand, that solution is more suited to new developments than to consolidated zones. Finally, parking management district is a good approach to solve the problem in new developments, but it is not a solution to consolidated zones already existing in most mature metropolitan areas.

3.2. New proposal approach

Given these limitations, a new approach of shared-parking is being presented in this paper, with almost universal applicability, optimising the use of the off-street private parking lots of

residential buildings and buildings with other uses.

Indeed, most of the urban buildings (residential and commercial ones, theatres, cinemas, etc.) constructed in last decades are provided with off-street private parking lots. A high percentage of these parking slots are vacant during peak hours of offices, shops, banks, etc., as shown in Table 1. This table illustrates typical weekly demand cycles for different land-use categories (Litman, 2006). As can be observed, rush hours of restaurants and office buildings are almost inverse, so if parking lots of these kinds of activities are included in the new shared-parking management proposal, the total number of slots to be provided can decrease to, for example, a half of the sum of the slots needed for each activity independently. The same occurs with other combinations, as office and residential buildings, taverns and offices, etc.

Table 1. Parking occupancy. Source: modified from Litman, 2006

		Type of activity			
Type of day period		Office	Retail	Restaurant	Tavern / Bar
Parking occupancy (Portion of peak demand)	Weekday morning	90%	35%	20%	2%
	Weekday noon	80%	55%	50%	10%
	Weekday afternoon	100%	80%	30%	15%
	Weekday evening	5%	20%	80%	40%
	Weekday night	10%	1%	40%	50%
	Weekend morning	10%	20%	30%	2%
	Weekend noon	15%	60%	50%	10%
	Weekend afternoon	15%	100%	40%	20%
	Weekend evening	10%	20%	100%	70%
	Weekend night	2%	10%	40%	100%

The values and peaks in the table can vary from one place to another, depending on the general habits. Therefore, a local study of parking demand considering local circumstances is recommended. As an example, parking slots needs for offices in Spain would decrease between 2 and 4 pm, but they would last until 7 or 8 pm in the evening, instead of ending at 5 pm.

Therefore, parking slots of off-street private parking lots of residential buildings, theatres, cinemas and entertainment buildings already existing in mature cities, are underused in peak

hours of the rest of activities.

Consequently, in city zones with mixed uses of land, if these parking slots were available for citizens who use their private cars for travelling to work, shopping, etc., this would be a very suitable solution to the explained problem, with an improved use of already existing resources, which lead to a higher sustainability of the system as a whole.

This solution can enhance the use of more environmentally friendly modes. For example, a large parking lot between the street and the door of a building can lead to an unpleasant walking experience, while providing off-street parking slots in nearby buildings, with clearly defined walkways, separated from cars, can encourage pedestrians (Stein *et al.*).

3.3. Involved parties

In the proposed solution there are several involved parties, in addition to the management entity. These parties will be named passive subjects, active subjects and non-participant owners.

3.3.1. *Passive subjects*

Passive subjects transfer their parking slots to the management entity for a limited or indefinite time, and the entity guarantees that they will have a parking slot available in their parking lot when they need it. Passive subjects have no obligation to vacate their parking slots if this is not convenient to them at a given time (an essential condition to cover exceptional situations as trips, illness, etc.). This will avoid that parking slot owners are discouraged from transferring them to shared-parking system for saving themselves inconveniences.

The solution must be flexible enough, considering different transfer forms, including direct lease of the parking slot to the management entity of a shared-parking system.

It must be guaranteed that the owner of a transferred parking slot will have an available space to park in the same parking lot in which the transferred slot is (in general, the basement of the passive subject's residential building), if this is the transfer form chosen. Passive subject will not always park in his/her own slot, but in some other slot that is vacant in the parking lot.

For that to happen, only parking lots with a minimum number of parking slots (50 might be an appropriate number) could be included in the system. Moreover, a peak-control system should be provided to prevent the parking lots to be filled to its maximum. This system requires the development of an appropriate algorithm for parking slot management, and that the owners (passive subjects) have access to these slots although the parking lot appears as filled ("no vacancy") for other users.

In exceptional cases when this cannot be achieved, the passive subject will have to go to another nearby parking place which is also integrated into the management system of shared-parking. Some kind of compensation may be specified for these cases.

3.3.2. *Active subjects*

Active subjects assigned to a shared-parking system get the possibility of parking by fee payment, as they would do in any other off-street public parking lot, but with the following additional advantages:

- The parking fees by the hour may be lower than in an underground public parking lot, because it is not necessary to recover the investment of the construction, as the parking lot already exists in the building.
- An active subject may park in any zone of the city in which there is a parking lot attached to the shared-parking system, instead of leasing a parking slot in a given parking lot, which is the usual method today.

In the case that the shared-parking initiative gets a good response from citizens, the possibility of using parking lots in other cities could arise, by means of agreements. This could be very convenient for holiday travels, sales representatives, etc.

Obviously, the same person may be the one who transfers his/her parking slot in a given building of the city during the time he/she does not need it (passive subject), and in turn use another parking slot (active subject) in other zone of the city, for example near his/her job, which has been transferred by a different passive subject.

3.3.3. *Non-participant owners*

During the creation and management of shared-parking, it is also necessary to take into account owners who do not want to participate in the system.

Non-participant owners will be, at first, reluctant to the inclusion of their building in the shared-parking program, due to the following reasons:

- ❑ A lower security perception due to the presence of strangers in the parking lot.
- ❑ Increased congestion due to the greater use of the parking lot. This would be rare to happen due to the relatively small size of the parking lots, and it would only be significant in those with design problems, such as a one-direction ramp (this problem can be improved during the inclusion process with the installation of a presence detection automatic traffic light).

Because of these drawbacks, the system should offer certain advantages to these owners to join, in return, in such a way that even if they do not participate in the economic benefits of this operation, they do profit from it somehow with advantages like the following:

- ❑ Improvement of the general lighting of the parking lot, as prior step to the implementation.
- ❑ Increased real security in the parking lot with active electronic surveillance and itinerant staff.
- ❑ In the event of accidental damages in vehicles, reparation and compensation will be simple due to the insurance policy of the management entity, and to the existence of security cameras which can lead to the identification of liable people.
- ❑ Exclusion of the obligation to participate in maintenance costs (cleaning, lighting, etc.), which will be taken care by the management entity.

These advantages should lead non-participant owners not to try to prevent the implementation of the system.

3.4. System management

System management should be centralized in one or a few public or private entities, with municipal support, and with enough number of parking slots in its charge to make them cheap to run and competitive with price and services. In this way, compatibility problems will be avoided among access systems, fees, information, etc.

The joining of off-street private parking lots of residential buildings to shared-parking system will be decided by property owners.

Parking slots of non-participant owners should be clearly identified, so that passive and active subjects know that they are not allowed to use that space. Appropriate sanction measures will be taken in case of violation of this rule, with compensation to the owner concerned.

On the other hand, in the event that any owner needs more flexibility in transferring its parking slots to the shared-parking system, parking slots could be signalised dynamically (red or green signs which shows on-line availability). This can be the case of an exhibition or congress centre, which has peak seasons or days, but there are other days in which the parking lot is almost empty. If some particular parking slots are not needed, the availability of this number of slots (instead of the total number in the parking lot) could be informed on-line. For example, if a congress centre which is joined to the shared-parking system has a parking lot with 500 slots, and it is foreseeing a congress with an estimated influx of 300 cars, the day when the congress starts the congress centre could show as available for shared-parking only 200 slots. On the other hand, if a large congress is going to be held, the day before it starts an order can be given that its parking slots are not available for shared-parking for the duration of the congress.

Active subjects attached to shared-parking will have a card or an active RFID (radio-

frequency identification) card which will allow them to access to any parking lot of the shared-parking system. This card will be associated to their personal data, including the bank account number to which the parking fees (and other established payments) will be charged. Entry and exit hours of the subject in each parking lot will be controlled by means of this card, in such a way that fees can be applied to automatically obtain monthly invoicing for the user. Fees may vary depending on parking lot location and time of the day or week (being, for example, a little higher in the more demanded zones and in peak hours). This type of system should be very flexible and not locked to a special type of tariffs. Even though the term hourly rate has been used widely in this paper, all other types of contracts could fit in this system, like daily, monthly and yearly rates.

The management entity will pay the contractual amounts to parking slot owners depending on the average occupation of the parking lot. These amounts can be different regarding the location of the parking lot.

The system management entity must have typical contracts to set the participation of both active and passive subjects. Such contracts must clearly specify every rule of the shared-parking system, stating explicitly the penalties or sanctions for failure to comply with them, the compensations to passive subjects and their application cases, the rules to evaluate the income owners will get, etc.

3.5. System technology

The key elements of the system are the following:

3.5.1. Access card of active subjects

Access control of every active subject to parking lots will be done by means of this card. It will facilitate monthly invoicing, and the determination of average occupancy of every parking lot.

The more convenient type of access key would be an active RFID payment system compatible with the one in use in the area's toll roads, which allow the instantaneous use and payment. These systems are fast, safe and could provide access and payment to non-subscribers without any prior procedure (usually at a more expensive rate than subscribers).

3.5.2. Security systems

The main security element of shared-parking systems will be the cameras of the closed-circuit television (CCTV) covering the entire area of the parking lot. This system is operated remotely and will rely on alarm procedures and backup in case of failure.

In addition, appropriate measures will be taken to prevent the access of active subjects to the building and their flats. In many cases, the doors to enter the residential building should be used as safety exits, in such a way that they cannot be locked by a key, so those doors should have an alarm to avoid its use by intruders.

3.5.3. License plate scanner

Regardless of payment or access control system, the identification of license plate numbers of vehicles entering and exiting the parking lot is a fundamental requirement from a legal point of view, in order to impose any sanction because of failure to comply the contract.

3.5.4. Communication systems

The success of shared-parking system is based on making an economic centralised management of the parking lots. This requires:

- ❑ The existence of a good communication system, which allows users to solve their problems easily and immediately.
- ❑ The existence of itinerant staff which can quickly get to the parking lot in case of incidence related to access and exit, security, etc.

In addition, the management system should be connected to a data network, so that active subjects can be informed about parking slot availability in each parking lot. This could be done through a mobile smartphone application or by means of the GPS navigator in the user's vehicle. This fact would positively contribute to the reduction of busy city traffic, as it would prevent a significant number of vehicles from going around a particular area looking for parking slots without knowing where they can be found.

3.5.5. Fees and free parking slot indicators

A distinctive panel must be provided in the entrances of parking lots attached to the shared-parking program. This should be sufficiently visible from the street, to get an easy identification of the parking lot by potential users.

The number of vacancies for shared-parking will appear in this panel, taking into account the safety margins to avoid complete filling of the parking lot (to prevent passive subjects without a parking slot in their residential building), and parking slots not available for shared-parking, either temporally (reserved by the owner, as the case of a congress centre already mentioned) or permanently (non-participant owners).

Furthermore, in the parking entry there should be a fee panel, so the user can know the parking fee that will be charged on his/her account.

3.6. Legal implications

For implementing shared-parking, it would be very suitable to have a regulation framework which allows an easy management of the system. That is: the police should be involved in sanction imposition due to failure to comply with the rules; vehicles which are not properly parked or which do not pay the fees can be removed from the parking lot in an effective, quick and economic way; and the existence of a fast police support to problems detected by security systems of the management entity.

In the same way, for the actual implementation of shared-parking systems, it would be necessary to amend certain regulations which require unanimity for agreements of the neighbourhood associations. Otherwise, shared-parking would be limited to new developments in which it would be implemented prior to sale, and therefore could hardly get enough parking lots to achieve its potential advantages.

4. Pilot project

Although at first glance the implementation of shared-parking may seem complicated, a pilot project could be done, and would determine the strengths and weaknesses of the solution, in order to get a massive implementation strategy.

Although this system would be good in a big city, a medium size one (population around 75,000 – 250,000) with high population density and mixed uses downtown would be an ideal place for the pilot project. Being the first one, it is advisable to choose one without major safety problems, with a strong sense of community and with determination to try what no others have tried before in order to improve their quality of life. Some of the economic advantages of the system are closely related to its scale: labour costs, communications costs and publicity will be much smaller in relative terms as the system grows.

This pilot project should include small residential parking lots and larger ones, and begin with agreements to have a starting critical size of around 2,000 parking spaces. In a fresh start like this, most of those spaces could belong to large public and private organizations that might be interested in outsourcing the management of their parking spaces with this system, or to a large parking owner who sees this system as a way to increase his/her incomes without building new infrastructure.

The success of the pilot project can be determined considering the ratio of parking lots added to the initiative in relation to the total of parking lots which have been considered or contacted. In this pilot project this ratio will not be very high, due to the owner's reticence to new and unknown initiatives. To avoid this problem the project must have an intensive marketing campaign in which benefits for parking lot owners have to be emphasized. A ratio

of 25% can be considered a success for this pilot project.

In the operational stage, the success can be measured as the ratio between the number of users (active subjects) of the system and the number of parking slots added to the pilot project. A ratio of 40% can be considered a success in this first project, although a better ratio can be achieved once the system is extended to more parking lots in the city.

5. Conclusions

An innovative solution to the need of parking slots in city zones has been presented in this paper. This solution, based on optimising the use of off-street private parking lots of residential or entertainment buildings, could outstandingly increase available space for parking in the cities, by making better use of resources already existing and underused.

Indeed, this system allows achieving a more complete use of an already built infrastructure with a limited expense in off the shelf technology and very low labour costs. Compared to a new infrastructure, it avoids the cost of new building; it could use cheaper and streamlined technology; and have much lower labour costs if the scale is large enough.

This paper has shown the solution feasibility, one possible way of implementation, as well as the advantages that it would provide, both for people who need to park, for people who transfer their parking slots, and for society as a whole. Table 2 provides a schematic overview of shared-parking operation.

Table 2. Schematic overview of shared-parking operation

	Passive subject (parking owner)	Active subject (parking user)	Non-participant owners	Parking manager	City
PROVIDES	- Use of his/her parking slot	- Fare - Compromise with plans that give steady revenue	- Tolerate	- Management - Security - Maintenance - Services - Insurance	- Legislative support - Publicity support - Security support
GETS	- Use of parking slot when needed - Profit - Security - Maintenance	- Simplified and cheaper rates and plans - Bigger offer - Parking closer to destination	- Active security - Infrastructure improvement - Additional free services (e.g., cleaning)	- Profit	- Transport efficiency - Available space for other uses - Decrease of traffic looking for parking

The base of the success of this system lies in the possibility of being done in a very economically efficient way. In order to be successful, there are many expenses from ordinary lots that should be avoided:

- ❑ Infrastructure expenses: most of them will already be built, and the equipment to be installed is standardized and will be connected to a centralised control.
- ❑ Labour expenses: centralising the system and having cleaning, maintenance and security staff working in different areas should make it more efficient.
- ❑ Organization expenses: this system should use flexible, standardised, and streamlined solutions, so that including new lots should be easy.
- ❑ Litigation expenses: Administrations wanting to promote this type of systems should provide a regulatory framework that avoids excessive litigation. For example, allowing agents to police the facilities and fine offenders, instead of having the system administrator suing the offender in a civil court.

- Security expenses: this system is based on the opportunity of cheaply using existing lots, but, in some complicated areas, the cost of the security requiring around the clock personal presence can be too high. In some cities or areas that do not have a feeling of security, getting the lot owners to join can be a daunting task, too.

City liveability would be improved with this solution, optimising existing resources, and ensuring a balance between different land uses in surface, avoiding the hegemony of private cars, and improving the city landscape. In addition, with the proposed information systems shared-parking will help to reduce busy traffic in the city, preventing a significant number of vehicles from going around a particular area looking for parking slots without knowing where they can be found.

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