A New System of Mobile Payments for On-Street Parking

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Summary

This paper presents several disruptive new technologies developed by TWS to substantially facilitate mobile payments for parking in open streets.

The methods are **suitable for use on either smartphones or as native applications (apps) built into the electronic systems of cars**. Some of the features require an inexpensive Bluetooth Low Energy (BLE) or RFID tag to be placed in the car, unless it is already part of the car's electronic system.

A companion paper describes new methods developed by TWS that facilitate payment in gated garages [1]. Together, these methods can become a truly **universal parking payment system**, which allows the user to use one payment method for all parking applications. This is completely new to the marketplace where, to date, pay-by-cell systems have mainly addressed on-street parking.

Our street parking payment methods lead to **user and enforcement officer experiences unmatched by any existing system**. Far fewer user-smartphone interactions are required in our system than existing pay-by-cell system.

Our TWS system provides the enforcement officer with knowledge of the locations of violating vehicles, greatly **facilitating targeted enforcement and enhancing the collection of fine revenues**.

These benefits are delivered by the following, patented ***technical innovations*** in our TWS system relative to existing systems.

1. Autonomous parked location determination by smartphone or vehicle
2. Autonomous vehicle ID determination by smartphone
3. Automatic renewal of parking session in street parking
4. Automatic closing of parking session in street parking
5. Display of parked car locations and session status on enforcement terminal
6. Automatic determination of vehicle ID by Enforcement Terminal using RFID or Bluetooth Low Energy (BLE)

1.0 Background: characteristics of existing parking payment systems

In the last several years, a number of companies have started offering cellphone based payment systems for street parking (commonly referred to as “pay-by-cell”). These include, Parkmobile, ParkNow, PANGO, and others. Of these, Parkmobile appears to have the highest market penetration. PANGO is a European company whose presence in the USA is relatively recent – it is the only company whose system (at least in the European version) identifies the parking location based on the GPS function in a cellphone. The US version uses zone IDs.

Pay-by-cell for parking in gated garages is rare. The reasons for this are unclear, although some trials and demonstrations have been reported.

Present pay-by-cell offerings follow a more or less common concept of operations, consisting of the steps described below. Typical steps in *existing* pay-by-cell parking payment are described below.

- Registration: The user registers for service with the service provider. Besides ID information required for any internet payment transaction, such as name, address and credit-card/bank-account details, the subscriber also registers the IDs of the cars (license plate numbers) and mobile phone numbers which will be used for the pay-by-cell service.

- Start Parking: A parking session is started when the user has communicated the following information to a server on the web, operated by the service provider.
    a. *Parking location (this determines the tariff, or parking rate)*. Typically, this involves the user reading a posted zone ID number (often pasted to a legacy coin meter) and entering it on his phone. Relatively recently, QR codes have been posted instead of a zone ID, which the user scans with his smartphone camera. Clearly, having to enter a zone ID number was recognized as a negative factor for user experience.
    b. *User ID*. The phone number serves as the user ID in all systems. A password is required for registration and for accessing the service provider’s website but, in most systems, users are allowed to store the password in the phone to avoid entering it each time that a parking payment transaction is executed. In this way, launching the app from a registered phone automatically submits the password for authentication by the server, transparent to the user, and takes the user straight to the parking payment application. This is not the best method from a security standpoint but, given the typical payment amounts involved, sufficient for risk management.

c. Vehicle ID. This is the car's license plate number. In the worst case (from a user experience perspective) this must be entered manually by the user each time he uses the app. However, most systems allow the last used plate number to be used as the first default and picking another ID from a stored list as the second default.
d. Duration of stay. The need to communicate this is determined by parking authority policy. In some jurisdictions, such as Washington, DC, the user is required to commit to a predetermined parking session time at the start of the session, emulating coin meters; in others, the user does not need to select a predetermined session time and pays only for the actual duration of stay. The need to select a parking time adds a step of user interaction in all systems.

Once the above information has been received by the server, it authenticates the user and sends a confirmation of the start of session. All systems allow the user to view the status of an active (open) session and to extend it remotely. Remote session time extension has been one of the major user benefits of pay-by-cell parking payment.

Another feature, also supported by most systems, is displaying the present parking rate and terms (such as maximum time) to the user *before* the session is initiated, allowing him to abort the transaction if he finds the rate/terms unacceptable. This has gained importance with the recent introduction of dynamic, demand-based parking rates by some city parking authorities.

- End Parking: Not all service providers allow the user to end an active parking session in all scenarios. Where the user is required to commit to a predetermined parking time, systems such as Parkmobile do not allow the user to close an active session. The thinking behind this may have been that, as the session is prepaid with no refund for unused time, it is moot whether the user closes the session before driving off. We will see that there are important validation advantages in incentivizing the user to close the session even in prepaid parking, or automatically detecting the end of the session, which is feasible in our TWS system.

2.0 Our TWS system and its advantages

Our TWS system is a pay-by-cell system enabled by an app downloaded to the smartphone, or a native app built into a vehicle. It offers the following major ***stakeholder benefits*** over existing systems:

A. *Substantial improvements in end user experience* (significantly fewer user interactions required)
B. *Substantial improvement in Enforcement Officer experience* (significant saving in Enforcement Officer's time/effort in performing targeted enforcement)
C. Attractive for incorporation into vehicle's electronic system

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Table 1 shows how the technical innovations in our TWS system support various stakeholder benefits.

Table 1 Technical Innovations in our TWS system versus Stakeholder Benefits

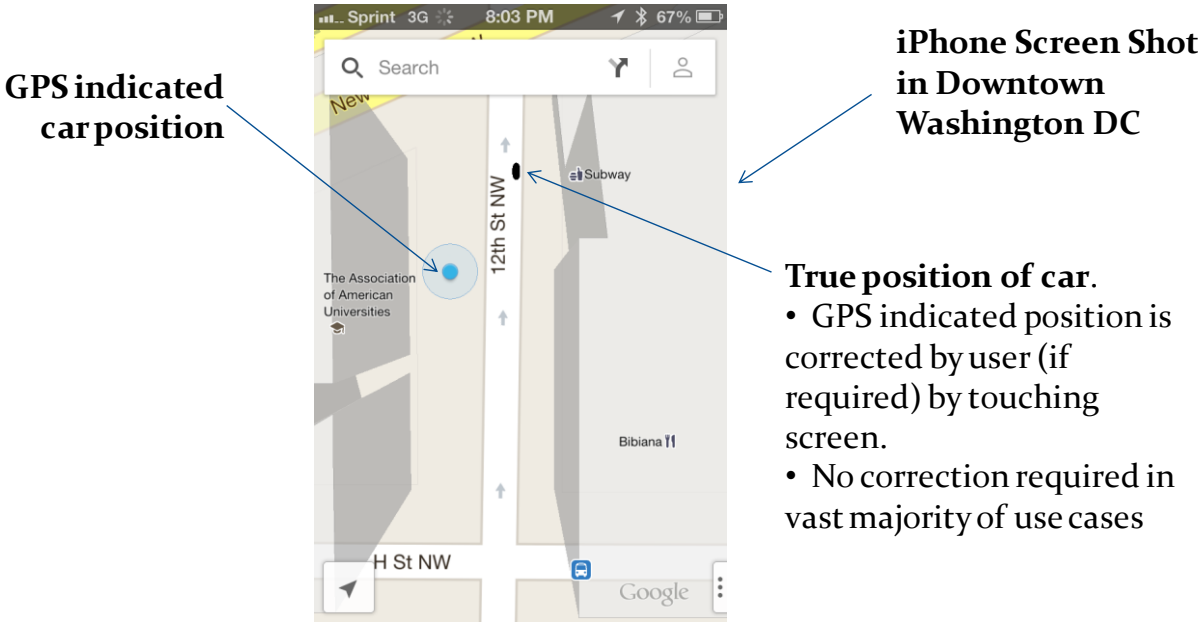
	Stakeholder Benefits		
Technology Innovations	Improved End User Experience	Improved Enforcement Officer Experience	Suitability for Incorporation into Vehicle Electronics
Autonomous position determination by smartphone or vehicle	√	√	√
Autonomous vehicle ID determination by smartphone	√		N.A. as phone is built into vehicle
Automatic renewal of parking session	√		√
Automatic closing of parking session	√	√	√
Display of parked car locations and session status on enforcement terminal		√	√
Automatic determination of vehicle ID by Enforcement Terminal using RFID or BLE		√	√

The following sections describe the technical innovations in detail and show how they support stakeholder benefits.

2.1 Autonomous position determination by smartphone or vehicle

The GPS function in the cellphone is used by our TWS parking app to determine the parked location. One possible reason why many pay-by-cell systems have avoided using GPS position is that the accuracy can degrade unacceptably in dense urban environments owing to limited satellite visibility and multipath.[1] Figure 1 below shows an iPhone screenshot of a GPS indicated position in downtown Washington DC.

Figure 1 GPS based parking location determination with provision for user correction



Our TWS system uses the simple expedient of allowing the user to correct, if necessary, the location indicated by the GPS function. In most cases the user does not need to do *anything* because the indicated position is sufficiently accurate (less than 5 - 10 m error is common in many urban and suburban environments). However, if the screen shows

[1] The ability of smartphones to provide accurate positioning in urban canyons is improving with the incorporation of Glonass receivers in addition to GPS, which allows more satellites to be seen by a phone for a given, constrained view of the sky. In 2020, the Third Generation Partnership Project (3GPP) – the global cellular technology standardization body -- has started work on supporting high precision location on smartphones, which has the potential to provide decimeter accuracy in benign environmental conditions. With this support, sub-meter accuracy should be available in most urban environments, making uncorrected, GPS-based car location identification feasible for parking applications. This is an example how the massive R&D investments in other sectors, such as wireless, can be leveraged by parking.

the car on the wrong street or inside a building, the user can point to an approximately correct position, as shown in Figure 1. Touch screens facilitate inputting the correction. Note that the accuracy required is no greater than a typical city block, as the parking rate is typically uniform over such distances. It will be apparent that *inputting a corrected position on a touch screen is much simpler than finding and inputting a zone ID or scanning a QR code on a legacy coin meter, as is the current practice in existing systems, and may be performed without the user leaving the vehicle*.

If our TWS app is native to the vehicle (built into the vehicle electronics) then greater accuracy can be achieved. A vehicle's positioning system will typically provide approximately 1 - 2 m accuracy compared to 5 – 10 m for a cellphone with good satellite visibility. The greater accuracy of a vehicle's positioning system stems from motion sensors and is also called "inertial assist". It should be clear from the above that there is greater synergy in building a location sensing parking payment system, such as TWS, into a vehicle's electronics than one which is based on reading zone IDs, which makes no use of the vehicle's superior navigation system.

For on-street parking, autonomous determination of parking location provides major benefits for many stakeholders. Pasting and maintaining zone ID labels or QR codes on every parking meter (before it can become eligible for pay-by-cell parking) is an operational burden, not only driving up the cost of the business but limiting its rate of growth. Our TWS system requires no on-street zone IDs or QR codes; therefore, the market penetration rate would be limited only by the time required to advertise and promote our system in different markets. Also, our system can address smaller cities where, for other systems, the revenues may not justify the cost of signage. The cost efficiency of our TWS system can allow us to be more competitive.

The parking authority also benefits. Signage space is very limited on streets, which are already cluttered with many different types of signs, especially in large cities. Figure 2 shows Parkmobile signs in the Washington DC market. It is clear that *there is no room for a second service provider*. This may force the parking authority into an exclusivity arrangement with the chronologically first service provider, locking out the benefits of competition indefinitely. ***Our signage-less TWS system enables payment service provider competition***.

Figure 2 Parkmobile Signs in Washington, DC

2.2 Automatic sensing of vehicle ID

In legacy systems, as described in Section 1.0, the association between phone ID and vehicle ID (i.e. which phone is being used to pay for parking which vehicle) has to be overtly established by the user, unless the association is the same as the last, default association. In our TWS system, the identification of the car is established automatically, transparent to the user, by a Bluetooth Low Energy (BLE) tag in the car. The vehicle ID is "advertised" periodically by the tag, which serves as a beacon.[2] Many new cars already have Bluetooth built into the infotainment system, which could also be used for this purpose.

Several user-smartphone interactions are avoided when the user does not have to enter the vehicle ID, which present systems require. This feature is of particular benefit where the vehicle is one that the user has never used before, such as a rental or fleet car. In fact, ***in addition to payment for parking, our TWS system could facilitate the issuance of rental cars to customers and subsequent rental payment*.** This would be done by establishing an ID link between the user's phone and the vehicle.

[2] The technical details of how this is actually done within the Bluetooth standard may vary from the simple explanation provided here. For example, the tag may advertise, not the vehicle ID but its own ID (indicating that it is a Bluetooth LE device). The smartphone recognizes that it is proximate to a Bluetooth LE device, engages in a short transaction and reads the data provided by the device, which in this case is the vehicle ID.

Leveraging this link could materially improve the user's car rental experience as well as fleet management.

2.3 Automatic Session Extension

It has been mentioned that some municipal parking authorities, such as Washington DC's Department of Transportation (DDOT), require by policy that, similar to coin payment practice, users must pre-commit to a certain amount of parking time at the start of a session. Entering the session time requires a few additional user interactions on the smartphone or vehicular user interface. To avoid this, our TWS system will offer its subscribers the option of automatic renewal of the parking session in small quanta, such as 10 minutes, with optional user notification. (The user may also choose to enter a prepaid session time, as in existing systems, if he so chooses.) The user will be expected to close the session before leaving the parked spot. However, if he forgets, ***our TWS technology can automatically sense movement of the vehicle away from the parked spot and close the session with a message to the user***.

If the parking session time comes up against a mandated maximum time (e.g. 2 hours during weekday busy hours), auto-renewal will be disabled and, at some period before the session time expires, the user will be sent a warning message. Auto-renewal and charge accumulation will also be suspended if the session time runs into a free parking period, such as in the evening.

2.4 Automatic Session Closing

Our TWS system automatically sends an End Parking message to the server when the car leaves the parked spot, regardless of whether the user has remembered to close the session. This determination is based on the position and motion of the car. The above approach is not so easy to do when the GPS of the smartphone, rather than that of the car, is being used. In other words, the position location function is tied to the phone and not to the vehicle – the user/phone can wander far away from the vehicle while the vehicle is still parked. Our TWS system has solved this problem by sending the End Parking message (in the case where the wireless device is a smartphone) *only when the in-car Bluetooth module can also be sensed*. The user is sent an advisory message when the session is closed automatically.

2.5 Improved Enforcement Officer Experience

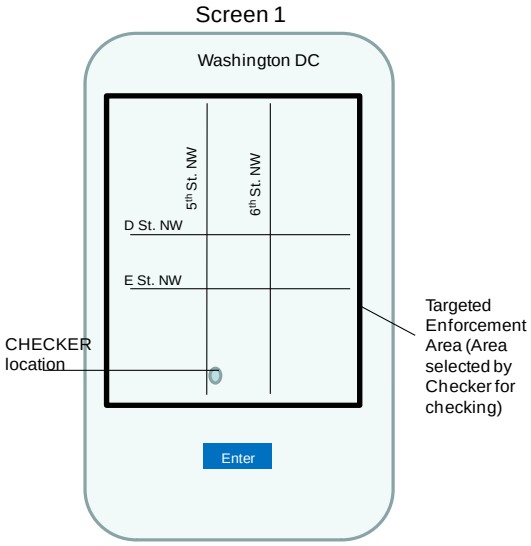
This is a major benefit of our TWS system. It has two aspects:

1. Display of locations of expired-session vehicles on Enforcement Officer's handheld terminal
2. Easy and rapid confirmation of the IDs of expired-session vehicles

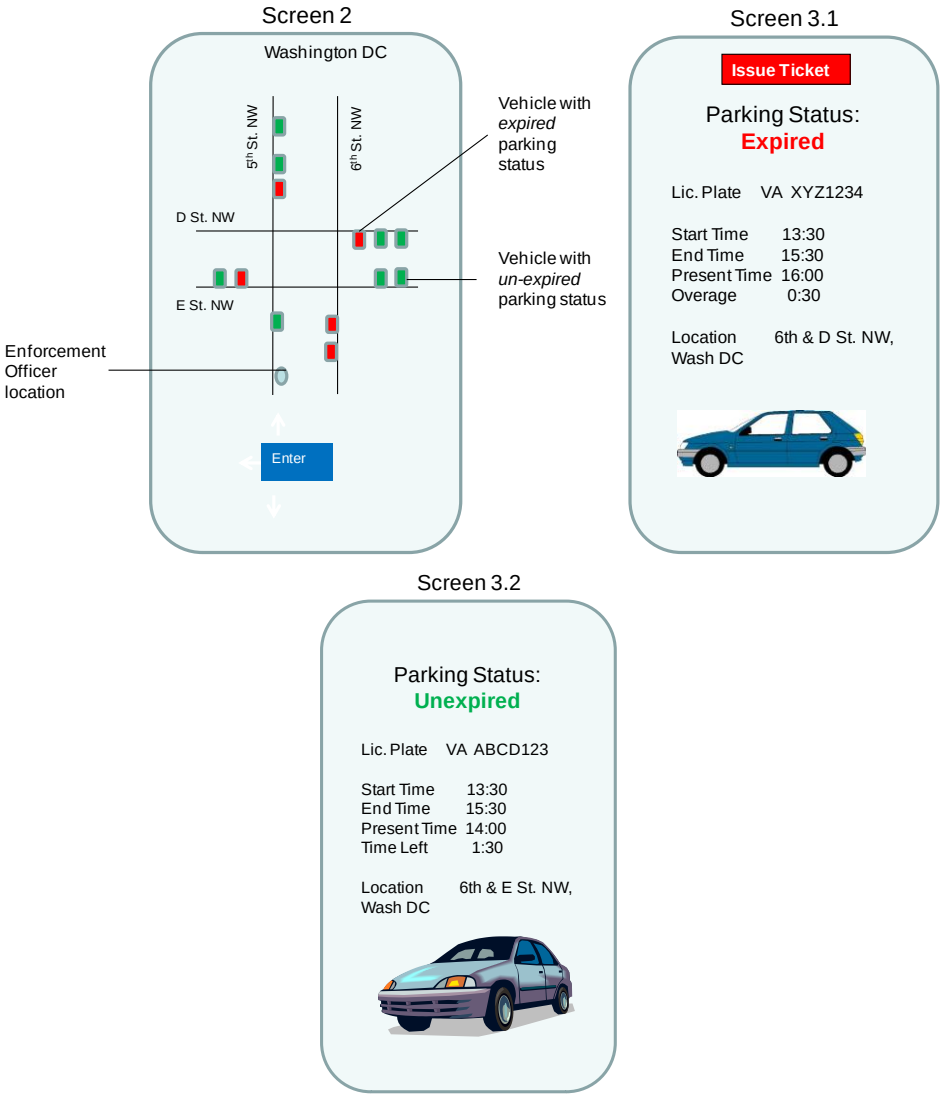
2.5.1 Display of locations of expired-session vehicles on enforcement terminal

The server downloads to the Enforcement Officer's terminal a map of the area showing the approximate locations of vehicles with different parking session status, as shown on Screen 2 in Figure 3[3]. The Officer may view detailed attributes of each vehicle and session by clicking on each vehicle icon, as shown on Screens 3.1 and 3.2.

Figure 3 Enforcement Officer's Terminal Screens



[3] Enforcement map may be chosen automatically by the Parking Application Server or manually by the Officer.



The meanings of different parking *status* conditions are explained below. The status is defined from the perspective of the *Parking Application Server.*

A session can be *active* or *inactive*[4]. An active parking session can have the following status:

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[4] A session is considered *active* unless it has been closed by one of the following means:

- The session was closed by user action.
- The session was closed autonomously by the smartphone or the car's built-in wireless device after detecting movement of the parked car.
- The Enforcement Officer has queried parked vehicles, found a violating one, ticketed it and advised the server thereof.

- Unexpired: the car's virtual parking meter in the Parking Application Server is still running.
- Expired: the car's virtual parking meter in the Parking Application Server has expired.

A *green car icon* is shown on the Enforcement Officer's display for *unexpired* cars. All these cars can be disregarded[5] by the Enforcement Officer; only the other cars, *red* or not, must be checked. A *red car icon* is shown for cars where the parking session has *expired*. These, hopefully few, cars can be ticketed right away.

A different icon (not shown in the diagram) could be used for cars belonging to other systems (where the Enforcement Officer's terminal is integrated with the servers of multiple parking payment systems). Empty spaces are shown for parking spaces that are not known to be occupied by cars of any system; they may be truly unoccupied or illegally occupied.

Integration with existing Enforcement Officer Terminals

Enforcement Officers already use handheld terminals for various validation functions requiring two-way communication with the servers of present pay-by-cell systems. In order to accommodate TWS as a second payment service provider, it is not necessary for the Officer to carry two terminals or even have two screens. It should be possible to integrate feeds from both TWS and the incumbent service provider's servers to develop an integrated display. This display would not only provide all the present functions of the terminal (for the incumbent services) but also provide the TWS functionality described here, which is essentially about providing the Officer with information about the locations, IDs and physical attributes of expired TWS vehicles.

2.5.2 Rapid/Easy confirmation of parked vehicle IDs

Armed with knowledge of the approximate locations of vehicles that are liable to be ticketed (informed by the Enforcement Officer's handheld terminal in our TWS system), the Enforcement Officer can proceed directly to those locations and confirm the vehicles' IDs. There are two reasons why the Enforcement Officer must visit each violating car, as opposed to issuing fines remotely based on status recorded in the Parking Application Server. These are: (i) by law, a parking violator must be issued a physical ticket that may be produced in court; (ii) there is a small chance that a user's

[5] Knowing that a car can be disregarded for checking is a contributor to the Enforcement Officer's productivity.

smartphone was turned off when he returned to his vehicle. This could create a false, *expired-session* status in the server, although the likelihood is small.

In our TWS system, two methods of RF verification are supported, both of which are substantially faster and more convenient than the present methods, which involve manual reading or electronic scanning of license plates. Our TWS methods are more facile and rapid because they are based on RF sensing. Either RFID or Bluetooth Low Energy (BLE) may be used, depending on the distance to the car from which inspection is required to be performed. The BLE method is always available as a default if the RFID tag is not present, as the BLE tag is required in the vehicle to identify it to the smartphone.

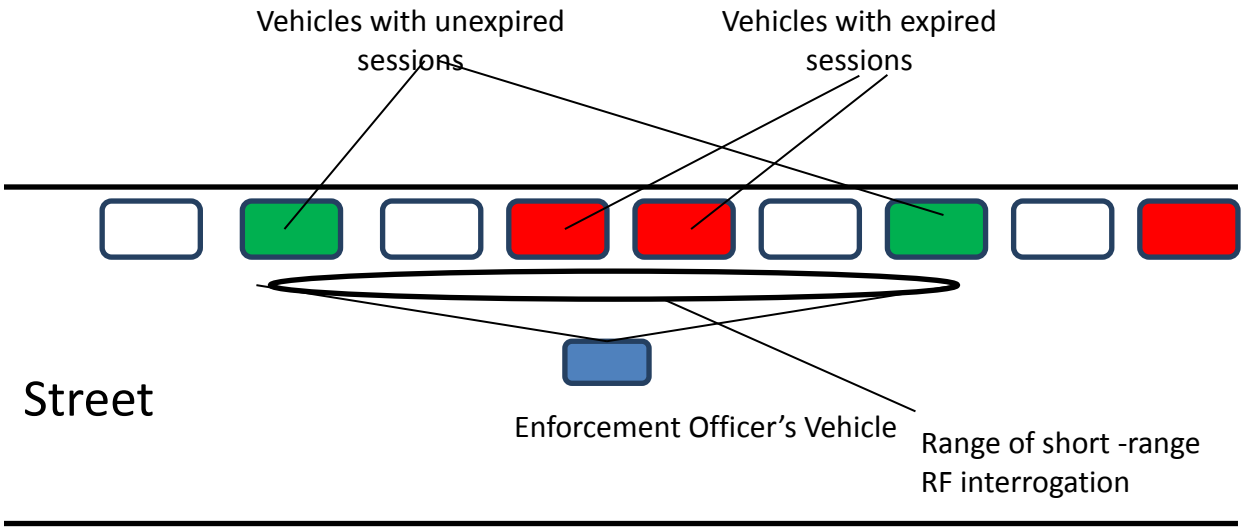
RFID has greater range and is conducive to drive-by verification. BLE has shorter range and is more suitable for walk around verification, which parking authorities may favor if there are substantial numbers of non-TWS vehicles which have to be checked by walking around. BLE is also more suitable for incorporation in a handheld terminal owing to lower power consumption.

Checking with RFID

RFID queries are issued from the Enforcement Officer's handheld terminal[6] while he is driving by the parked vehicles on an inspection vehicle at low speed, as illustrated in Figure 4.

[6] His terminal is equipped with an RFID modem which will issue queries and the tags in the vehicles will respond with their ID's as per standard RFID protocols such as ISO18000C. On the Enforcement Officer's terminal, the IDs received from the tags are matched with IDs downloaded from the server to identify the vehicles whose sessions have expired.

Figure 4 Drive-by checking with RFID



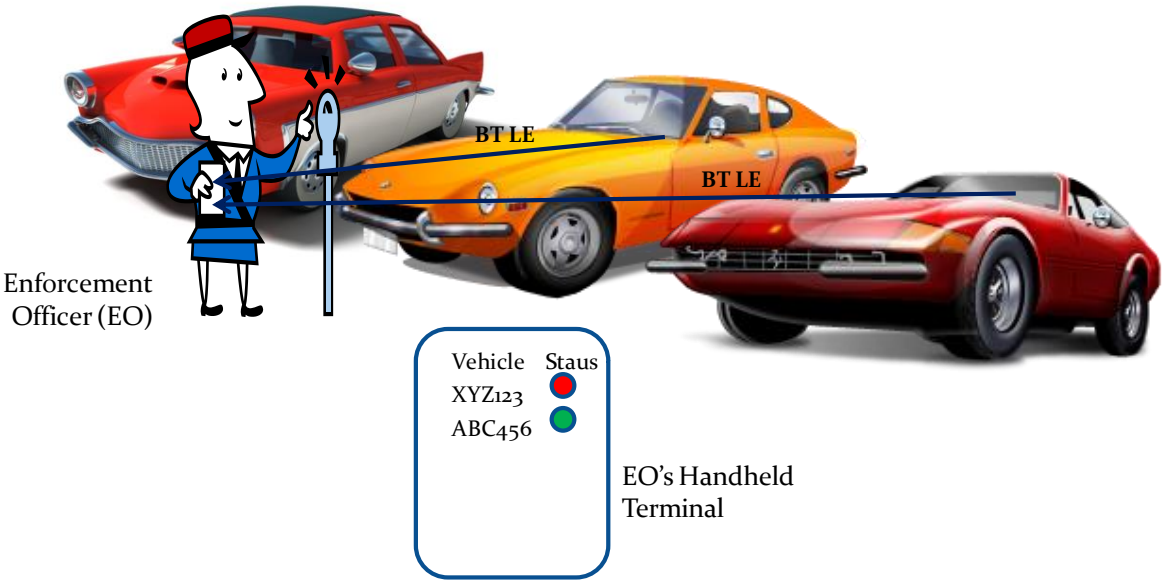
Each query will generate responses from all TWS vehicles that are in coverage range of the RFID query signal. The responses can be distinguished by the RFID protocol and will be filtered by the officer's terminal to indicate the IDs with expired status. To facilitate rapid recognition of these vehicles, the terminal (on demand) displays additional information about individual vehicles, such as license plate number and image, as shown in Figure 3 (Screens 3.1 and 3.2). Thus, the process of identifying the offending vehicles is extremely rapid and easy for the officer.

The RFID tag that needs to be placed in the car in our TWS system is extremely inexpensive (a few dollars retail price).

Checking with Bluetooth Low Energy (BLE)

In an alternative scenario, the officer may be inspecting vehicles on foot. In this case, he will be sufficiently close to TWS vehicles to detect their BLE ID broadcasts (approximately 1/s) from tags in the vehicles. No queries need to be issued by the officer's terminal to read vehicle IDs. The BLE tag will be sensed automatically by the officer's terminal when the tag is proximate to the terminal. If a BLE tag ID corresponds to that of a violating vehicle, that ID will be indicated on the terminal, as illustrated in Figure 5.

Figure 5 Walk-around vehicle ID verification with BLE



If we compare our TWS enforcement system with legacy practice, the advantages become clear. In legacy practice, the Enforcement Officer visits all vehicles parked in metered areas and, as the first task, has to determine if a vehicle that *appears* to have an expired session (e.g. parked in front of a red flagged coin meter) is a subscriber to an authorized pay-by-cell system, such as Parkmobile. He makes this determination by uploading (from a handheld terminal) the license plate number of the vehicle – the process may be assisted by a license plate scanner. Given that (a) this must be done for every vehicle, and (b) the legacy process is not conducive to drive-by checking from a distance, as in our TWS system, the substantial advantages of our system should be apparent. It may be noted that legacy pay-by-cell systems have actually increased the Enforcement Officer's workload as, previously, he would simply write a ticket if a vehicle was parked in front of a red flagged coin meter (or, for multi-space parking meters, the displayed paper ticket in the vehicle indicated an expired session).

2.6 Incorporation into vehicle electronic systems – why TWS is a better candidate than other parking payment systems

It is expected that many future cars will be equipped with built-in smartphone modules with the infotainment screen acting as the user interface. Some systems, such as Onstar, already provide this capability for basic, emergency phone services. It is expected that, in the future, the services will expand to include many using cellular data, such as parking spot finder, parking payment and others.

While it is conceivable that the present pay-by-cell services could be incorporated into a vehicle's electronics, there are aspects of our TWS system that make it more attractive for such incorporation. These are described below.

- In our TWS system, parking position is determined by GPS, not by on-street signage. By 2025, to support various autonomous driving systems, vehicular location accuracy, using high precision location technology, will be at decimeter level. Location based parking payment greatly improves user experience over signage-based payment systems. Even today, a car's navigation system provides far greater position accuracy than a smartphone owing to wheel motion sensors, e.g. 1 – 5 accuracy can be achieved even in urban canyons. This can be used to further improve user experience in our TWS system -- no user correction of the indicated location is *ever* likely to be required. In a signage-based system, the superior navigation capability of a vehicle is irrelevant. There is clearly greater synergy between the inherent capabilities of a car's native electronic systems and our TWS payment system, compared to signage-based parking payment systems.
- An in-car Bluetooth module is required in our TWS system for facilitating rapid enforcement. The Bluetooth system of the car's infotainment system can be designed to do double duty as an announcer for car's ID (license plate number).
- Automatic session closure (supported by TWS but not by any other system), which is key to rapid targeted enforcement, is easier when the parking payment app is built into the car, as the position location system is always tethered to the car. In signage-based systems, this synergy does not exist as they are not based on position sensing.

All other differentiating features of our TWS system over legacy systems are equally implementable on an app built into the car and on a smartphone.

Because our TWS system involves far fewer user interactions with the app than any legacy system, and more space is available on a car's display screen for user I/O than on a smartphone, ***one-touch parking payment is possible with a car app when our TWS system is used.***

3.0 Summary of Innovations and associated Value Propositions of our TWS System

On-street Parking

Innovation relative to present systems	Benefit	Beneficiary	Comments
Autonomous vehicle location sensing based on GPS	No need to enter zone ID or scan a bar/QR code	User	Substantially **greater convenience**.
	No on-street signage is required	Parking Authority (e.g. City Department of Transportation)	Competitive benefit of **multiple parking payment service providers in a given market**.
		Parking payment service provider	Reduced operational cost and deployment time. **Lower costs enhance service provider competitiveness**.
	Conducive to in-car implementation	Car manufacturers	Accuracy substantially improved over cellphone GPS. **Enables One touch parking**.

On-street Parking (continued)

Innovation relative to present systems	**Benefit**	**Beneficiary**	**Comments**
Automatic sensing of vehicle ID by smartphone	User does not have to enter vehicle ID when he changes vehicle	User	**Reduces several user steps in present systems**.
Enforcement Officer's Terminal indicates location and status of parked vehicles. Confirmation of vehicle status/ID by RFID query or Bluetooth LE.	Rapid and facile validation (targeted enforcement)	Parking Authority/Enforcement Authority	**Significant cost savings through enhanced Enforcement Officer productivity**.
Automatic Parking Session Renewal	Reduces steps required in entering pre-committed parking time	User	**Greater user convenience**
	Encourages user to close session	Parking Authority	Provides unambiguous information about *still parked* vehicles. **Reduces Enforcement Officer workload.**
Automatic detection of Parking Session Closure		Parking Authority	Provides unambiguous information about still parked vehicles. **Reduces Enforcement Officer workload.**

References

[1] S. Dutta, N. Rydbeck and P. Chakrabartti, “A New System of Mobile Payments for Gated Garage Parking”, TWS White Paper, Version 3.0, 9/17/2020.