Cloud based ticketing

Next generation fare collection
Cloud based ticketing

Next generation fare collection

For more than 20 years transport operators have experience with automating their fare collection process. In almost all cases the operator issue (contactless) smart cards to their customers and roll-out sales and validation terminals at their stations and in their busses and trams. The customer loads an electronic ticket and/or stored value on his smart card. When entering and leaving the transport network, the customer presents his smart card to a validator. These validators verify that the fare product entitles the customer to use public transport. Simultaneously the validator consumes the fare product and/or debits the stored value.

In this white paper UL presents its vision on the next generation of fare collection systems. Not only is the ‘dot-on-the-horizon’ discussed but also the compelling reasons for these new systems and the roadmap towards this future.

The paper targets public transport operators and public transport authorities with an existing fare collection system as well as operators and authorities considering to roll-out a new system. Especially when starting from scratch with automated fare collection there is a big opportunity to include the lessons learned in other AFC systems.

UL sees the next generation of fare collection systems being built on top of the big achievements in communication networks and server technology. Over the last years the communication networks became mobile, fast, reliable and highly available. In addition the processing speed and storage capability within the server technology has increased. The combination of communication networks and server technology is currently called the cloud. The cloud enables everybody and everything to be always online everywhere. The consequences for payment, mobile phone and ID systems are enormous. UL expects a big impact from this cloud on fare collection as well.

The three areas where the cloud has the biggest impact on fare collection are (see figure 1):

**Identification**

The main purpose of identification in a cloud based ticketing system is to link the customer to his central transit account. A vast variety of different means of identification can be used for this. Examples are the existing contactless transport card, a contactless bank card, a virtual card on a mobile phone, and a contactless student/citizen card. The only limitations are the requirement to secure the ID via authentication, and the support of the ID at the infrastructure of the operator.
Fare Calculation
Based on the validations captured during usage of the transport service, the back end calculates an aggregated fare. The moment of fare calculation can be days after the actual usage.

Payment
Cloud based ticketing supports multiple ways to fund the transit account, e.g. a pre-paid wallet, a direct debit or a credit transfer. In addition, fare payment in the cloud can also be directly from the debit or credit bank account of the customer.

Cloud based ticketing elegantly decouples identification, fare calculation and payment. Hence, new developments on these areas can be used in fare collection without affecting the other system.

UL has the clear vision that the majority of data and logic currently present in transit terminals and fare media will move to the cloud, leading to cloud based ticketing (see figure 2). As a fare medium the customer only requires a contactless device that stores an ID and offers a means to prove this ID is authentic. The terminals of the transit operator have their own ID and will act as a relay between the fare medium and the back end. The actual transaction between the customer and the operator occurs in the cloud. The back end implements all the required logic for the primary fare collection processes.

Sales: the customer purchases a fare product online.
• Fulfillment of the purchase is limited to link the fare medium ID with the fare product stored in the back end. Nothing of the purchase is stored on the fare medium, neither during the sale nor at a later moment.
• The cloud based ticketing system can support all current and future fare products ranging from pre-paid and pre-specified to pay-now, post-paid, and post specified.
• Payment for the fare product is done using the existing payment technology. Both remote and proximity payment can be supported due to the isolation of payment from the rest of the sales process. In other words, the means of identification are completely decoupled from the means of payment.
• Instead of presenting the fare medium to a terminal (contactless reader) to exchange the ID, a customer could still manually enter his ID. This customer ID is either engraved on the plastic card or present in the mobile app. Alternatively the customer could use his email address as ID.
• Optionally, transport operators can create dedicated transit accounts in the cloud, as the equivalent of 'stored value' on the card. Funding this ‘wallet in the cloud’ can be done similar to other
pre-paid accounts.
• Finally in the case where cloud based ticketing is fully implemented, sales is completely possible without a ticket vending machine. The actual delivery of the fare product is just its storage in the central account of the customer.

Validation: the customer presents his fare medium to a terminal (e.g. a gate or a validator)
• The fare medium authenticates itself to the back end, mediated by the terminal. Authentication of the back end towards the fare medium is not required since validation does not lead to any changes in the fare medium. Hence, there is no risk of unauthorized changes on the fare medium.
• The terminal requests the back end to authorize the travel by sending its own ID together with the presented fare medium ID.
• The back end verifies if a valid fare product is related to the presented fare medium ID and sends an authorization response message to the terminal.
• The terminal acts upon the receipt of the authorization response message. A gate will either open or remain closed. Both a gate and a validator will give visual and audio signals.
• Optionally the terminal displays fare product information to the customer.
• The back end performs actual journey determination, fare calculation and billing. For performance reasons these activities can be done after the authorization response is sent to the terminal.
• The back end is able to perform complex fare calculations like monthly fare capping. Both the time and processing possibilities of the back end are much larger than of a terminal.
• In case of a direct debit, the back end is able to charge any kind of account (e.g. a credit account, a debit account, a mobile phone account, an online-payment account).
• Note that the above described validation process is not the only possibility. Cloud based ticketing allows alternative implementations of the validation process for example using long-range communication.

**Inspection:** the customer presents his fare medium to the handheld of the Revenue Inspection Officer.
• Similar as during validation, the fare medium authenticates itself to the back end, mediated by the handheld.
• The handheld sends an inspection request to the back end including the presented fare medium ID and its own ID.
• The back end acknowledges the inspection request to the handheld.
• Based on the validation information the back end determines if the customer was entitled to travel. The back end charges a correction fee from the customer in case no valid fare products were present to justify that travel. This correction fee can be included on the bill in case of a post-paid relation, or during the next purchase. In the latter case the back end can decline any subsequent validation authorization request until the correction fee is paid.
• Note that in the exceptional case of ‘not always on-line’ handhelds, the actual verification of the customers eligibility for the journey is verified in the back end after the registrations are uploaded (e.g. at the end of the day). The actions in case of unjustified travel are the same as stated above.
• Similar as for validation, cloud based ticketing enables alternative inspection processes where long-range communication technology is used. In fact this means that the ID and the authentication from inspection device is moved to the back end.

The cloud based ticketing system supports both anonymous and registered customers. Of course, the anonymous solution will have limited privacy concerns. However, it is in the operator’s interest to know its customers. Hence in return of sharing customer details with the transport operator, the customer could receive benefits like multiple payment options, reduced fares etc. Also in the registered solution, the privacy of the customer shall be properly protected.

The apportionment, clearing and settlement between the different actors in the fare collection scheme is not affected by cloud based ticketing. The existing clearing house systems can be used.

**What is in it for everyone**

The primary actors in fare collection are the customer, the transport operator and the transport authority. For the sake of this paper the transport authority acts as scheme owner, card issuer and product owner of interoperable fare products. Cloud based ticketing adds value for all three actors.

**Customer**
The benefits of cloud based ticketing for the customer are:

*Flexibility in used fare medium type*
The cloud based ticketing system can support multiple types of fare medium. The only constraint is that the fare medium supports one of the communication protocols of the terminal. Examples of possible fare media are the currently used transit contactless smartcards, contactless payment cards, contactless ID cards like a student card and NFC enabled mobile phones. The
authentication protocol often requires key exchange. See notes below.

**Flexibility in the used payment means**
Both during sales and during validation it is possible that funds are to be transferred from the account of the customer to the account of the operator. The cloud-based ticketing solution gives customers the flexibility to select different kinds of account. Examples are a bank account, a mobile phone account, or an online payment account like PayPal. The only requirement is that the back end implements the payment protocol or simply interfaces with a Payment Service Provider.

**Single check-in and check-out**
Cloud-based ticketing for a multi-modal and multi-operator transport network relieves the customer from the obligation to check-in and check-out multiple times per journey (i.e., per operator and per transport mode.) This way, each operator can implement its specific fare rules per transport mode. Terminals are often limited to calculate with only one set of fare rules. In cloud-based ticketing the fare calculation is done in the back end. Every transport operator uploads its fare rules to the back end. After decomposition of the journey, the back end applies the right fare rules for the multi-operator and multi-mode journey.

**Enhanced customer support**
Due to the online nature of the cloud-based ticketing system, the customer could instantly get information from the back end about check-in or check-out validations that took place, remaining balance in the transport account or online purchases. The information can both be pulled and pushed. A customer with an internet access device can query the back end. A customer with a mobile phone (not necessarily NFC enabled) can receive SMS messages from the back end. This especially is a benefit in comparison with the current card-centric off-line fare collection systems. These systems have a time-delay of hours between the moment of check-in and the actual presence of the check-in transaction in the back end. Similarly online sales in those systems typically have a time-delay between the purchase of the fare product/top-up and the actual delivery.

**Notes**
- Accepting for example TfL issued Oyster card in the Dutch OV-Chipkaart system requires TfL to exchange their ticketing master keys with Trans Link Systems in The Netherlands in order to do an authentication. This is caused by the symmetric cryptography used for authentication. In the extreme case where authentication is done online with the Oyster back end, the key exchange is not required.
- Accepting bank issued contactless payment cards in a cloud-based ticketing system only requires the insertion of the public key from the payment scheme into the back end system. This is caused by the asymmetric cryptography and the one-sided authentication.
- If the number of transport networks accepting contactless payment cards increases, the seamless travel experience for the global traveler becomes true.
- The importance and relevance of the different benefits depend on the kind of customer. Public transport customers are often categorized in occasional and frequent travelers.
- Connecting cloud-based ticketing with other cloud services from payment and government makes it possible to track and trace the behavior of the customer. Standard techniques can be used to mitigate this privacy concern. Examples are a ‘derived ID’ or ‘temporal IDs’.

**Transport Operator**
The most important benefits of cloud-based ticketing for the transport operator are:

**Decreased capital expenditure (capex)**
Instead of a large amount of expensive terminals in the current card-centric off-line fare collection systems, the operator has the cost for the simple and hence cheap terminals.

**Reduced Total Cost of Ownership (TCO)**
Since the back end in cloud-based ticketing implements most of the logic any change in this logic affects only this back end system and not the thousands of terminals in the transport network. For example the roll-out of a new fare product or the upgrade of the security is now much simpler and hence much cheaper.

**Lower costs for customer support**
The cloud-based ticketing system enables transport operators to provide a range of self-service options like the ones mentioned in ‘enhanced customer support’.
support’. This significantly reduces the current amount of customer support questions. Additionally, the cloud based ticketing system equally provides these services to the help desk and the gate-line staff allowing them to better deal with customer support questions.

Improve operations
In a cloud based system, the data on actual usage of the public transport is real-time available for the transport operator. This enables the transport operator to pro-actively act or directly react upon for example a bottleneck.

Flexibility in defining & implementing new products
Instead of complicated implementation & roll-out scenario’s the new products can be defined centrally (on a few host systems) and rolled-out fairly quickly to customers.

Transport Authority
The benefits of cloud based ticketing for the transport authority are:

Reduced card issuance costs
Since a cloud based ticketing system could accept multiple kinds of fare media the costs for the transport authority to issue cards can be reduced. For example a university city where the students population has contactless student passes issued by a university. Another example could be a city with a lot of tourists all having a contactless payment card. Accepting these kinds of fare media would save the transport authority the costs of issuing cards to these groups.

Reduce retail network costs
The terminal in a cloud based ticketing system is just a relay between the fare medium and the back end. This gives transport authorities the possibility to use existing contactless readers in laptops or NFC phones or to issue contactless enabled USB dongles. In all cases the customer is enabled to do home-loading of purchases. Note that alternatives exist. For example the customer could manually enter his ID during sales, use his email address or a barcode.

Increased customer loyalty
In general the purpose of any loyalty program is to enhance the loyalty from the customer to the transport network. The cloud based ticketing system gives the transport authority a number of options to set-up enhanced loyalty schemes. Examples are using the amount of kilometers travelled in the network as a ground for reduction on goods and services outside the transport network. The other way around is equally possible after the retailers of these non-transport goods are equipped with small and simple readers next to their point of sale terminal that enables the registration of loyalty points in the back end of the cloud based system.

Advertisement platform
The real time information about check-in and check-out information is valuable as an advertisement platform to retailers in station areas. On an ‘opt-in’ basis customers could couple their mobile phone number to the fare medium they use. Retailers could send messages to these phones with offers targeted to the circumstances of the customer.
Value added services
The cloud based ticketing solution gives the transport authority the opportunity to contract providers of other transport services that are used in the mobility chain of their customers. Examples are parking, taxi, bike rental and car rental. Especially the deployment of the acceptance infrastructure to these additional transport services will be very simple and quick. Along the same lines, the cloud based ticketing solution could also be used as a ‘city card’ covering a wide range of city-life aspects: library, museums, events, public services, etc.

Third Party
Actors other than customers, operators and authorities are all grouped under the term ‘third parties’. A very common example is the ‘third party retailer’. One main benefit of cloud based ticketing for this third party retailer is the ease to integrate it with its point of sale terminal. Instead of a direct link between the point of sale terminal and the ticketing terminal, the point of sale terminal shall connect with the back end of the cloud based ticketing system. A small and simple contactless reader on the desk of the retailer connected to the back end suffices for the delivery of the ticketing related purchases.

Another third party in the cloud-based ticketing is an issuer of contactless cards. This ‘third party card issuer’ will benefit from an increased acceptance of its cards. In addition, this ‘third party card issuer’ could perform several ticketing services on behalf of the transport operator/authority.

Finally, cloud-based ticketing can be connected to a large variety of cloud-based services. Examples are road-tolling, event ticketing, government services. The connection of all these different cloud services combined with a generic ‘access device’ creates the ‘smart city experience’.

Roadmap
The cloud based ticketing ‘dot-on-the-horizon’ might seem futuristic for transport operators and authorities with existing card-centric off-line fare collection systems. However, UL is convinced that operators and authorities following the right path towards this future start harvest the benefits on the go. UL advises operators and authorities to make steps towards this desired future during every regular update cycle of their ticketing infrastructure.

The UL envisioned phased approach towards cloud based ticketing is also relevant for operators and authorities considering the roll-out of a new fare collection system. Especially when the cloud capabilities in their jurisdiction are limited, the UL road map enables them to achieve a fare collection system with as much as possible cloud based features.

In general, UL advises operators and authorities to focus their investments to upgrades of their ticketing infrastructure that are steps towards the ‘dot-on-the-horizon’.

UL sees the following route towards cloud based ticketing (Figure 3):
1. Implement post-paid product
2. Prepare infrastructure
3. Go mobile
4. Explore ID and payment means
Implement Post-paid Product
The first step for transport operators and authorities with a card-centric off-line fare collection system is the roll-out of a post-paid product without any change to the existing infrastructure. Without the issuance of new fare media, an upgrade to the terminals or an always online connection of the terminals, additional logic can be built in the back end. Actually, the implementation of a post-paid fare product means the duplication of the journey determination and fare calculation logic from the terminal in the back end. In addition account management and billing logic shall be added to the back end to complete the post-paid fare product offering. All four components can be re-used by the back end of the ultimate cloud based ticketing system.

A post-paid fare product in a card-centric off-line fare collection system requires (see Figure 4):
• Issuance of a fare product on the (already issued) fare media of the customers granting access to the transport network any time and any place without a debit on the purse.
• Implementation of journey determination, fare calculation, account management and billing logic in the transport back end.

The fare collection process with a post-paid product consists of the following elements:
• Every validation leads to a ‘zero-value’ transaction uploaded to the back end.
• The transport back end calculates the fare based on these ‘zero-value’ transactions.

• Billing the customer for the actual public transport usage.

Credit risks inherently related to a post-paid product can be mitigated as follows:
• Issue the post-paid fare product only to registered customers.
• Perform a credit check on these customers before issuing the post-paid fare product.
• Put the specific post-paid fare product on the blacklist in case the customer does not pay his bill. The standard blacklist and blocking logic of the card-centric off-line fare collection system is used for this.
• Note that in case of contactless payment applications the credit risk might be carried by the issuing bank.

Typical examples of a ‘post-paid’ product
are an ‘account based product’, a business card, and a corporate card.

Prepare Infrastructure
The second defined step that UL sees on the route towards cloud based ticketing is the preparation of the infrastructure. The following infrastructure upgrades are foreseen:

Certify contactless interface
An essential part of the cloud based ticketing system is the contactless interface between the fare media and the terminal. In order to deliver the promise that different contactless media can be accepted, UL advises operators and authorities to certify the implementation of this contactless interface in the terminals. Existing transport terminals are often created to only accept one fare media type. As soon as a second fare media type is allowed in the transport scheme, all kinds of issues appear in the interoperability between terminal and fare medium. This reveals that the contactless interface implementation in the terminal is actually tuned towards the contactless interface implementation of the single fare media type.

UL advises to certify against the EMV Contactless Level 1 parameterization of the ISO 14443 standard. EMVCo is the certification authority behind this with a global reach to enforce compliance of the contactless payment terminals. In addition, MasterCard has certified the NFC implementation of more than 180 mobile phone types against this EMV Contactless Level 1 standard. Finally, the contactless payment cards are certified against this standard as well. Hence, hardly any interoperability issues are expected when transit schemes with EMV Contactless Level 1 certified terminals decide to accept additional fare media types like NFC phones and contactless payment cards.

Invest in always online connection between terminal and back end
Transit terminals can be divided in ‘on-board’ and ‘on-platform’ equipment. UL advises transport operators and authorities to invest in an always online connection for at least ‘on-platform’ equipment. For fleet management vehicles have nowadays more and more an always online connection. UL advises in this case to connect the ‘on-board’ equipment to this always online link as well.
After having these always online connections, UL advises to upgrade the existing transit terminals to send real-time transaction messages over these always online interfaces to the back end. On the other hand, terminal management could be done over these always online connections as well.

**Sufficient memory in terminals**

Although a little against the philosophy of cloud based ticketing, UL advises to reserve memory space in the terminal to deploy an EMV payment application. Actual roll-out of EMV payment technology should be done after a careful business case analysis that is part of the ‘explore payment means’ step. This memory reservation is only relevant in combination with this step.

Note that if for example access cards are used for fare collection, the ticketing terminals require an extra application to interact with these access cards. Also in this case the terminal requires sufficient memory and processing power.

**Go Mobile**

The third possible step for transport operators and authorities with a card-centric off-line fare collection system is to go mobile. In most cases the word ‘mobile ticketing’ is associated with an NFC mobile. However, a number of ticketing use cases can be implemented in phones without NFC.

**Card enquiry**

After establishing a link between the phone number and the fare medium a customer can present his fare medium to a simple contactless reader with an always online connection to the back end. The back end reads-out the content of the fare medium and sends a summary of this content in a text message to the mobile phone linked to fare medium. This is one of the first-fruits of the infrastructure preparation step ‘always online’.

**Validation confirmation**

After establishing an always online connection between validating terminals and back- end, this connection can be used to inform real-time the back end about a validation event. Using the link between a mobile phone number and the fare medium, the back end could push this information to the mobile phone or, the mobile phone could pull this information from the back end. Note that the fare products are still on the fare medium.

**Online sales via mobile enabled websites**

A relatively easy step to do is make the existing online sales websites accessible for mobile phones. The actual delivery of the online purchases can still occur via the existing channels (e.g. dedicated delivery devices, ticket vending machines, or validators and gates) or via a new channel using the simple contactless reader always online connected with the back end.

**Remote self-check-in**

Using the GPS co-ordinates and linking the transport account in the back end with the mobile phone, customers could perform a remote self check-in by sending a text message to the back end reporting time and location and validation type to the back end. Using this information the back end can calculate the fare and charge it from the registered account of the customer.

Of course, an NFC enabled mobile could greatly leverage the advantages of cloud based ticketing:

**Home loading**

An NFC enabled mobile phone can act as the simple contactless reader always online connected with the back end. As such an NFC enabled mobile phone could deliver the online purchases directly to the fare medium. The NFC enabled phone acts basically as a Ticket Vending Machine.

**Alternative fare media type**

Obviously an NFC enabled phone can be used in the cloud based ticketing system as an alternative fare media type. Note that the fare medium only carries an ID and implements an authentication algorithm. Hence the requirements for security are not as high as for emulating a fare medium in a card-centric fare collection system.

**Proximity self-check-in**

An NFC enabled mobile phone could both act as a vending machine and as a gate. Hence, the customer could perform the ‘check-in’ on his fare medium.

**Card emulation**

The most well-known usage of the NFC enabled mobile phone (possibly enriched with MIFARE™ technology) is to emulate the fare medium. Hence, the complete transport application together with the purchased fare products is present on the phone. Combined with a user interface application the information on the card
content like purse value and transaction history can be displayed. Combined with a remote management interface, the purse can be topped-up or fare products can be loaded remotely.

Finally, value added services complementing fare management can be provided on a mobile phone (without NFC). Examples are real time passenger information, check-out alerts and other location based services.

Explore ID and Payments Means
A fourth step towards cloud based ticketing is to explore alternative IDs (tokens) and payment means. The philosophy behind cloud based is to use a single card/token for all the services. One area to explore by the operators and authorities is non-fare payment. UL observes two trends in this area: either the fare-payment solution is used for retail payments, or the retail payment solution is accepted for fare payment.

Fare payment solution in retail especially in regions with a low number of bank issued payment cards, the transit card is easily adopted for retail payments. In the card-centric off-line system, the integration between the cash register and the point of sales terminal is often proprietary. For the cloud-based system, the integration is often easier because standard technology is used. The cash register has to inform the back end about the amount to be debited. The point of sale terminal only reads and authenticates the ID of the customer.

Retail payment solution in transit
For regions with a high number of bank issued contactless payment cards the acceptance of these cards in transit is attractive. Several ticketing systems around the world have proven this concept. A payment card can straightforwardly be used to pay a fixed fare. A variable fare requires additional infrastructure also used for a post-paid product. Note that the preparation of the front-end infrastructure is a prerequisite for this.

UL advises operators and authorities to investigate payment outside transit using the same fare medium but relying on EMV technology. Dependent on the objectives of the transit scheme there is the choice to use the EMV technology white-labeled and use the established transport brand for it, or to join one of the global payment networks and use dual branded fare media.

The ICAO specified electronic passport plays an important role in the area of IDs. However, the current authentication algorithm including the machine readable zone is too slow to use in public transport. However, the existing citizen cards and national ID cards are often faster. Actual subscription for the cloud based services can be done with an e-signature application. Often national ID initiatives include an e-signature application.

In all cases, UL advises the operators and authorities to use existing open interface specifications. In case of a proprietary interface specification, UL advises operators and authorities to own these specifications. This enables them to incorporate whatever new technology that will emerge in the future to their current system.
Contribution of UL

The Transaction Security division of UL is established as the result of the merge of Collis, RFI and Witham. The combined strength of these three renowned industry players uniquely positions UL to guide, assist and support operators and authorities while implementing cloud based ticketing.

UL is eager to contribute during the define, design, develop and deploy phase of every step. Typical services are:

Shaping the future
• Discuss strategic choices with operators and authorities
• Take the current infrastructure into account

Infrastructure upgrades
• Assist to bring the front end devices online.

Harvest the first fruits
• Roll-out the post-paid fare product

Accredited Services
• Certify front-end equipment against EMV Contactless Level 1 specifications.

Conclusion

To conclude, UL sees the following trend in ticketing:
• From card centric to cloud centric
• From closed loop to open loop
• From single token to multiple tokens
• From single purpose to multi-functional

The cloud based ticketing and migration path presented in this whitepaper is aligned with all of these trends.

UL has identified a number of rewards for the customer, the operator and the authority on the road from the current ‘card-centric off-line’ ticketing system to the future ‘cloud based’ ticketing system. In order to achieve these rewards, it is important to take the right way. UL is uniquely positioned to advise, guide and assist operators and authorities on their journey towards the cloud.

About UL Transaction Security

UL is a world leader in advancing safety, and is also committed to making the digital world a more secure place. UL’s transaction security division provides independent, expert business and technology advice and end-to-end test services and tools for the mobile and payments domains to ensure security and compliance.

We have set up our testing and certification facilities in different parts of the world to enable us to serve our customers locally. From within the different regions, our experts provide EMV migration assistance, strategic advice on mCommerce implementations (incl. NFC/TSM/HCE/BLE), payment security advice, cloud-based fare collection advice, PCI audits and more, whilst also delivering mobile and payments test tools. UL enjoys the accreditations from Visa, MasterCard, Discover, JCB, American Express, PCI, EMVCo, GlobalPlatform, eftpos Australia and many more organizations in the mobile and payments industry.

Want to know more?
Please visit our website for locations and contact details or email info@ul-ts.com.