ORT: Thinking outside the box?

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The toll industry has enjoyed significant success with the implementation of electronic toll collection (ETC). Traffic queues are reduced, customer service has increased, and capital expenditures associated with the construction of expanded plazas have been deferred. In addition, throughput capacity has increased from 400 vehicles per hour to over 2000. Yet, the productivity benefits of ETC are not without their challenges. Most notable is the design and implementation of the lane/roadside architecture.

We mention this because as our industry begins to ponder the most effective means of implementing solutions and strategies associated with designing and effectively deploying economical solutions for Open Road Tolling (ORT) and cashless transactions, we believe the timing is appropriate to pause and consider what is required in ORT lanes. Should the architectural concept of lane controllers and roadside computers as we know them today continue by simply building on the concept that has it origins in the manual and automatic coin machine toll lanes? Or should a fresh systems analysis be done in order to truly sieze the benefits of technology and utilize it to the fullest extent? We believe the latter or course and the purpose of this article is to ask the question, Why not think outside the box?

For many, the concept of thinking outside the box is viewed as risky, costly and something that should be avoided. In another words, go with what you know. If we had done the same in the past, ETC and its evolution would never have become reality. As electronic toll collection matured over the last 15 years, we slowly modified our thinking about toll collection in general. We began to move away from gates as a violation enforcement technique and began to depend on image capture systems and violation processing methods as an effective means of enforcement. We developed ETC-only or dedicated lanes by converting from mixed-use lanes, which was the only realistic, practical approach as tag subscription rates increased over time. However, with tag subscription reaching a 50% penetration, we now have the opportunity to consider the question anew, how do we maximize not only the productivity benefits of ORT, but also the economical benefits that new technology offerings and the application thereof provide without necessarily lugging the baggage of the current ETC era into the next.

This article presents one view of the ORT systems environment. It is purely conceptual. Nothing has been tested or is in production. It is intended to create a "strawman" of a conceptual systems environment. The premise of this concept is that the philosophy of processing all toll transactions in real-time and in the lane is archaic. Rather, we need to rethink what we consider a transaction. Today a typical lane transaction is comprised of checking account balances, writing messages to patron toll displays, controlling gates, etc. But in the era of dedicated ETC and ORT, does it need to be? Customers of high speed ETC interact with the system, not in the lane at the time of the transaction, but at the end of the month when an accounting of the month's transactions is summarized transmitted either in the form of a bill or an account statement. Thus is real time processing of ETC transactions still required and can we simplify the roadside architecture by minimizing the lane transaction processing or eliminating it all together? In an ORT environment there is no need to process in the lane. Vehicles are moving through at highway speeds and their occupants are unable to read patron toll displays, respond to gates or pay with cash. What action is possible in response to a patron display or message in an ORT environment?

Consider an approach wherein the transaction processing is done in a centralized location (i.e., back office) at a later instant in time and the sole purpose of the lane equipment is to assimilate the various sensor data into transaction packet for each vehicle and transmit this information to the back office for processing. Thus, the lane and roadside equipment would be limited to collecting transponder data, vehicle classification information and license plate images. Certainly, sensor input must be assembled for each vehicle in the lane and provisions must be made to ensure that RFID reads are not mismatched with classification data or license plate images. Hence, the function of lane or roadside hardware in this scenario is reduced to one of an aggregator of sensor inputs rather than a processor of transactions.

The advantages of this scaled down lane equipment approach are considerable. First, the network of computers could be significantly reduced from one processor per lane to one per plaza or roadside location. Less capital costs, lower maintenance costs, simpler computer networks and less chance of system failure. Simplified networks significantly reduce the complexity of time synchronization, transaction processing and maintenance. This represents a significant cost savings while at the same time reduces the risks of systemic failures. In today's systems we strive to replicate the effect of each transaction throughout the entire network before the vehicle has a chance to reach the next plaza lane for fear that an account balance might go into deficit. Each toll transaction therefore creates messages and updates that are transmitted to each of the other nodes in the network. Scheduling and routing network traffic is a significant challenge. Most of this network traffic could be eliminated if the network were simplified. Imagine the transaction processing simplification of going from 200 nodes on a network to 10-15 nodes and the ensuing reduction in transaction messages.

Such a reduction in nodes or processors in the network represents a large reduction in recurring capital costs. Toll operators replace lane controllers on a 3-5 year cycle in order to ensure that equipment parts are available and that processors can be maintained. Each time this occurs the processors must be physically replaced, software tested for compatibility and then loaded onto each machine and inevitably modifications to software performed. Each time modifications to lane controller software or a new version of third party software is released; microprocessors are reloaded with the new version. Computer software licenses are required for each of these microprocessors and the license fees can be considerable. Reducing the number of computers in the network reduces the license fees that must be paid. Network simplification also results in a more stable network since there are fewer nodes that can fail and subject the toll operator to a loss of revenue.

The History and Evolution of Electronic Toll Collection

Radio frequency identification is not a new technology. Electronic toll collection first began to appear in the U.S. in the late 1980s and was an outgrowth of RFID applications in tracking animals. The New Orleans Crescent City project, Dallas, Texas and Oklahoma were three of the first fully operational applications. Early in the history of ETC, concern was expressed that revenue might be lost with the new ETC system. Especially when compared to the certainty that existed using gates in a manual collection environment. Accuracy of transponder reads of 99.96% was more or less a known quantity and over time became the accuracy requirement specified for the entire transaction. Four in ten thousand accuracy requirements were comforting to toll operators accustomed to stopping every vehicle with a gate and ensuring the correct toll was collected before the vehicle was released. This requirement was however difficult to attain in an ETC environment and to maintain over long periods of 24/7 operation. Few business rules or expectations were modified as it pertains to accuracy, reliability or security in this new environment of ETC. Axle-based classification, gates and other devices from the stop and go manual collection era were continued into the new ETC era.

Even as we begin to enter the ORT era of toll collection, these rules and devices persist as a requirement. Rather than attempting to segregate the ETC environment from the manual collection environment, we attempted to integrate the two creating complex operational environments and computerized systems. Our assumptions and perspective were based on collection methods that require actions to take place in the lane. Technology was able to take us into the ETC era but our biases about toll collection remained a part of the ETC implementation.

Open Road Tolling

Many have suggested that the next era in toll collection will be all-electronic open road tolling. This cashless, high speed operation will depend upon image capture technology for violation enforcement and highly integrated processing systems for vehicle registration tracking and mailing. But what must take place in the travel lane and what equipment configuration is necessary to create ORT?

A potential compromising factor of ORT is the necessity to close several through lanes of high speed traffic to repair or maintain equipment components. In the ETC era there was rarely a need to close more than one lane of traffic at a time and this occurred in a relatively low speed physically contained lane. Maintenance in the lane will be a significant economic and safety factor in open road tolling. Some have proposed an overhead structure design that allows for maintenance from above the lane.

If we continue to operate from the same perspective and with the same assumptions as we have in the ETC era, equipment configurations will assume the need to track vehicles from one lane to another to ensure a match of RFID read and image capture. If we will continue to process transactions in the lane and proliferate hardware components in the lane, the probability of closing the high capacity, high-speed ORT lanes will increase. Further, more hardware in the lane will increase the probability that the system will malfunction. All of this would suggest that an attempt should be made to reduce components in the lane.

How can we reduce the need for lane equipment as we move from electronic toll collection to open road tolling? What are the essential functions that must take place in the lane and what is the minimum equipment configuration to accomplish these functions? If we design for a minimum number of events in the toll lane, we must have at least the following: an indication that a transaction has begun (lane wake up), vehicle separation (if more that one vehicle can be in the lane at one time), communication with the transponder, classification of the vehicle, a license plate image capture and a concatenation of these events for each vehicle. It is not necessary to process the transaction, determine account balances etc. and send a completed transaction to the plaza computer, these functions can be performed at the plaza or host computer at some later point in time. Images can be disposed of when valid transponder transactions occur for customers with sufficient balances, accounts debited and video tolling transactions created for customers a valid account and license plate identification. Business rules can be altered to prevent account balances from going negative, alleviating the need to forward transactions to all plaza locations.

Of critical importance in any system of toll collection is that the correct customer be charged the toll in accordance with their vehicle classification. It is also crucial to match the RFID antenna read with the correct video image information. Otherwise, a toll customer may receive a violation notice associated with another vehicle. The conceptual framework of manual collections did not account for this, since only one vehicle could be involved in a stopped transaction at any point in time. This is more of an issue in dedicated ETC lanes because they were still physically separated and the likelihood was small of a mismatch of RFID read and violation image. In express lanes and ORT lanes, this concern becomes more probable and problematic. If it were possible to reduce the longitudinal distance from the antenna read to the image capture, it might become impossible for a vehicle traveling at 60 miles per hour to switch lanes in transit. If possible, one of the great concerns of open road tolling would be eliminated.

Vehicle classification is another factor that is carried over from the manual transaction era of toll collection. Axle-based classification is a relatively good surrogate of size and weight and has been used in toll collection throughout history. It has continued as the classification system of choice in the ETC era. There are few open road tolling applications in existence today but of those, several use a "small, medium and large" classification system in place of axle-based classification. While it is not necessary to simplify vehicle classification systems, revenue collection accuracy may be greater with a simplified system. In either case, the requirement is to collect revenue consistent with size and weight which is reflective of use of the highway.

Conclusion

Can it be done? The possibility is thought provoking. What we do know is that there is a tendency to carry over stale requirements and assumptions from one toll collection era to the next. Considering the many new technologies developed since the early 1990s, we should not eliminate possibilities based on existing requirements. The suggestion of this article is that perhaps we should start with a blank sheet of paper, rather than existing requirements and continuing to build complex technological solutions to fit an old paradigm.

There will likely be some manual toll collections in the future and there will certainly be dedicated ETC lanes and mixed, manual/ETC lanes. These environments should also be analyzed for the possibility of applying new technology or combinations of technology.

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