Initial Architecture Assessment – Satellite Vehicle Tracking and Telecommunications

Pay-As-You-Drive Road Pricing

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TABLE OF CONTENTS

1 OVERVIEW

1.1 Introduction

This document is part of a series of architecture deliverables to provide governance and costing for new ICT initiatives based on new or amended business processes with baseline functional and non-functional requirements.

These deliverables are

1. **Initial architecture assessment**
2. Solution Architecture Specification
3. Logical Architecture
4. Infrastructure Architecture
5. Program of Works

This document is highlighted in red.

1.2 Purpose

The purpose of this infrastructure architectural assessment is to allow all parties to view the architectural options and issues involved to provide the configuration of infrastructure software, firmware and hardware, to fulfill business processes required for pay-as-you-drive road pricing, within a specific timescale of six months.

This document has been drawn up based on information sourced from technical resources and architecture documents. In addition, it is presumed that the infrastructure functional capability is provided by a standard JEE platform with a secure portal, application and data integration. An appropriate gateway technology from the device services to the software platform is pre-supposed

The architecture assessment is also made in view of a holistic end-to-end set of technology services, in accord with best practice service oriented architecture.

1.3 Architecture 'big picture'

The pay-as-you-drive road pricing of vehicles is a new way of ensuring a user pays approach to road usage. The associated ability for carbon emission reduction is a welcome response to global warming and on-going climate change.

The initial implementation involves installing satellite tracking (GPS) antennas and in-vehicle devices with firmware/software. Analysis of data captured measures distance driven.

GPS co-ordinates are transmitted via GSM or UMTS network to a tracking server. The mediated tracking data is transmitted via a gateway to an integration capability, for further

processing, in terms of rating, journey aggregation, and preparation of customer accounts.
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At this point the in-vehicle functionality is about simple asynchronous measurement of GPS data, and the return transmission of traffic statistics. However industry trends indicate that the direction of travel is to allow for synchronous communication to offer drivers a range of communication options, for example add-on location-based services.

It is predicted that within a few years, vehicle owner/drivers will be offered subscription services to other vehicle telecommunication functions, particularly location based services such as navigation and local information data services.

There are a steadily growing number of device types able to collect GPS co-ordinates from vehicles, including the mobile phone.

It is considered that satellite tracking will become a standard vehicle capability in the short to medium term, as this functionality is already popularly available.

As content providers offer services for a range of device types, it is highly advisable to use a solution architecture sufficiently flexible to take account of future directions. The gateway architecture is very important, as this is where flexible services are required to be interoperable with different service providers.

It is not advisable to become locked into one particular device type. An open architecture for position data mediation is likely to be of benefit to vehicle owner/drivers by providing a wider, more flexible range content offerings.

GPS satellite positioning event data is captured, mediated, and used for rating in a bill calculation process so that vehicle owner/drivers only pay for the exact distances driven, rather than the number of times they pass through a toll entry zone. .

A data integration hub feeds operational data stores to provide the enterprise information systems and business intelligence value from the collected journey data.

Journeys have to be aggregated on a vehicle basis. Traffic statistics are calculated on a road usage basis using a statistically significant sample. The rating engine has to update cumulative account totals for query by customers through a variety of means, including web self-service and SMS messages. All of these operations have to happen in as near real-time as possible.

Billing and invoicing are to produce monthly accounts for delivery to customers by a variety of delivery means, as determined by the local authority. The basis for billing calculations are a set of tariff rules for distance traveled, potentially by class of road and pricing plan. Discounts may be applied at billing time based on factors such as class of user, and calculation of carbon emissions by vehicle type.

Real-time billing is a very important element going forward into service delivery to vehicle owner/drivers.

An interface into the billing tariff calculation rules is an essential part of transparency to vehicle owner/drivers. Likewise, access to journeys driven. Infrastructure failover mechanisms are required to provide resilience. Cached calculations are required to ensure web self-service performance. The number of web hits, initially modest, is forecast to grow exponentially as journey replays become a popular pursuit.

This means the technical infrastructure, hardware, firmware and software, all have to be highly scalable.

- Servers have to be configurable, and flexible in terms of CPU, I/O, with the least network latency possible.
- Customer access while initially through the internet, can be expanded to include other devices such as mobile phones.
- Technical services have to be global or common where possible, technology services formed to take advantage of on-demand platform and network configuration.
- Data has to be centrally managed, and readily accessible, with consistent definitions.
- The solution has to handle very large data volumes which will continue to grow exponentially. This implies a deliberate policy to deal with the incoming data volumes in terms of size, storage, archiving, security and update mechanisms.
- The billing component has to support flexible billing models, and it is important to make the best use B2B services to existing billing systems, and new billing systems that will easily deal with flexible tariffs and discounts able to be applied on usage and also at billing time.
- There has to be a system to provide clear traceability between business requirements and the implementation of the business logic as technical services. This is to enable ready replacement of technology improvements .

1.4 Current Situation

There are currently some excellent small scale implementations of pay-as-you drive, however this it is very important to employ a solution architecture that will scale. The solution elements have to fit with a strategic view of the growth in data collection, billing, tariff simulation, journey replays, and the associated hosting infrastructure and network. The considerations have to be

- Flexible position data collection architecture
- Flexible gateway architecture
- Industrial strength data integration architecture
- Optimisation of data collection and storage
- Scalability of hosting and network infrastructure.

This requires a managed plan to provide scalability for the least overall cost, within a reasonable distance of the business requirements, in planned phases. It is essential that the capacity to manage the large data volumes be kept in view as a primary goal. Large data volume collection and handling is an area of specialist knowledge and expertise.

The interface between the device data collection and the telco network is also very important.

A degree of device architecture flexibility is required to ensure that data is transmitted over telco networks in a way that takes advantage of network latency.

In the very near future, vehicles will come equipped with GPS collection devices, and currently they are easy to buy and install. Hand-held devices and mobile phones also have GPS capability and vehicle owner/drivers will want these devices to be plugged into their vehicles. These developments are expected to become standard and cheap in the short to medium term, viz the exponential growth in the location-based services market.

These factors need to be considered for optimum re-use of the current technology for a long-term strategic pay-as-you-drive road pricing solution.

The major components of the implementation are:

- Device position data collection and transmission
- Data mediation.
- Wireless network gateway
- Integration technology to route data
- Data store that requires scaling to teradata volumes
- Rating and billing
- Portal for user interaction

Areas to optimise potential data traffic latency are

- Wireless network gateway
- Data transformation procedures

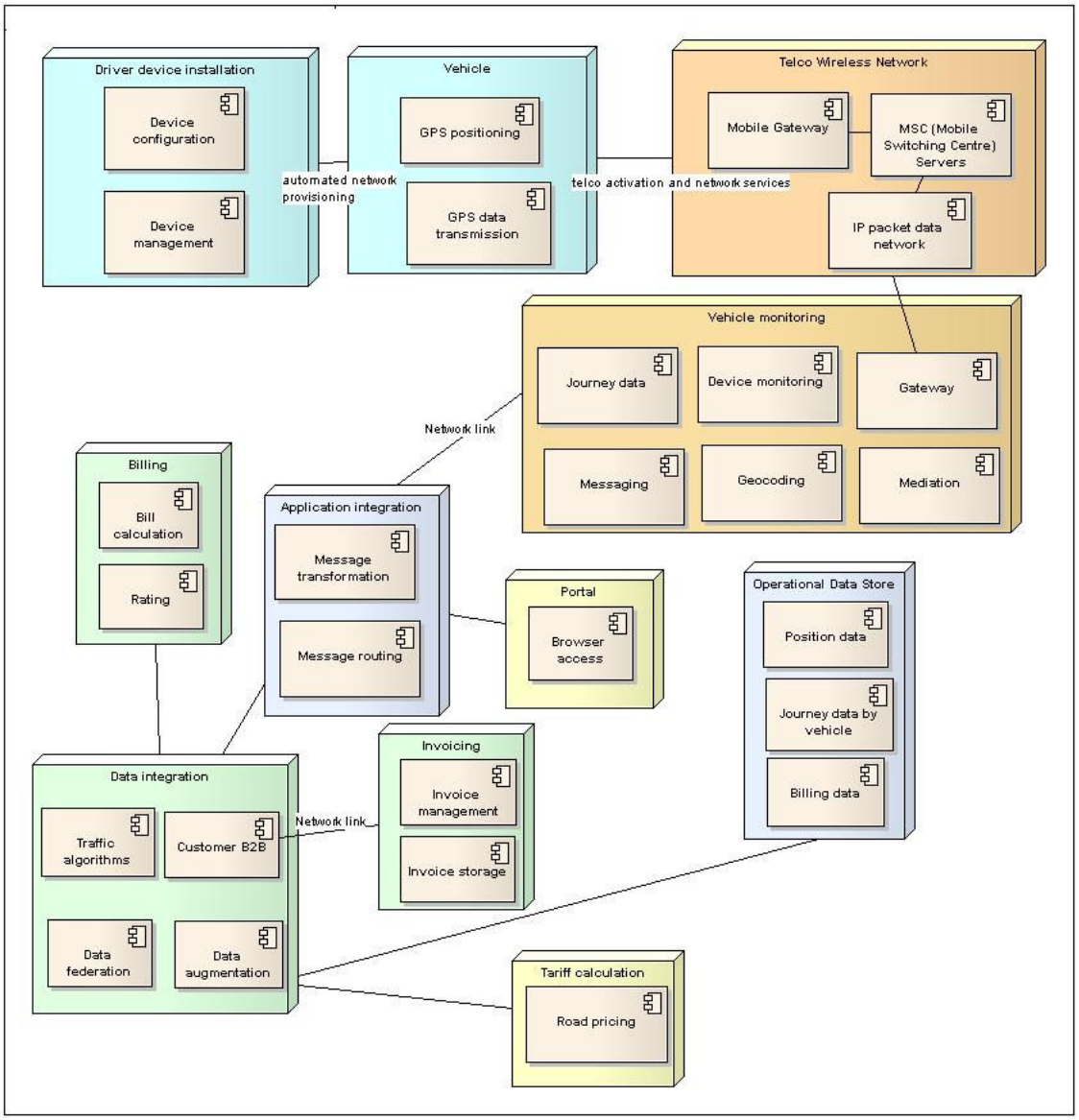

Figure 1: Logical component deployment overview current PAYD

1.5 Network Overview

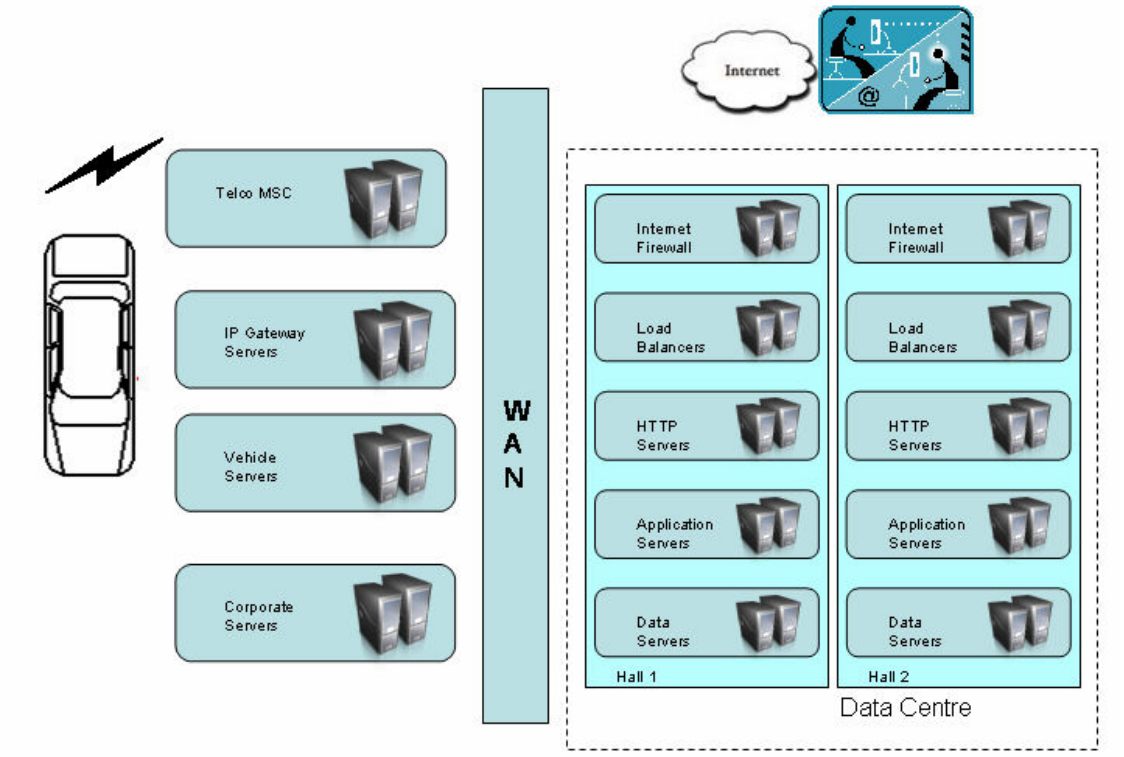

Figure 2: Network deployment overview

The hosting/network overview including network peers is as follows:

- Vehicle transmission of GPS data over telco wireless network
- Telco gateway
- WAN links to integration hubs hosted on servers
- ODS (operational data stores) in RDBMS servers
- Billing, GIS, invoicing, journey replay applications on a variety of application platforms
- Network links between components minimum of 100 MB links
- EMC SAN managing storage

1.6 Opportunities

The major opportunity to arise is the ability to add services such as location-based services, and broadcast content for vehicles in the medium term. As vehicle devices become more sophisticated and a range of interactive services become available in the marketplace, service providers would need to be in a position to offer services without the need to re-architect, re-design or re-build the infrastructure.

In addition there would be opportunities to offer discounts through intelligent analysis of usage patterns and flexible tariff structures, to encourage optimal driving. Carbon credits could be calculated on an individual basis, and encouragement offered for low carbon emitters. In addition, being able to provide carbon emission reduction has a real monetary value on local and international carbon markets.

There is also a major opportunity for the area of data collection and manipulation, to provide traffic and road monitoring statistics. This is also a saleable commodity. This will happen if and only if a proper data architecture and data management strategy is put into place in advance, to facilitate large data volume collection and analysis.

1.7 Challenges

One major challenge is to design systems that will scale to meet the volume of data required. Trac-car is able to provide a stable coherent set of technology application services on a secure scalable hosting infrastructure with high speed network services with accurate capacity planning, able to respond to growing volumes of data from different devices.

Another major challenge is to accurately identify the business processes involved in road pricing, so that the technology services may be catalogued, owned and costed correctly.

Another essential activity to provide accurately costed essential infrastructure services is to ensure that functional and non-functional requirements relate directly to road pricing business requirements.

In addition, the following information is required:

1. Service interfaces mapped to logical data architecture. This is essential for reuse, as industry experience proves that unmapped interfaces are the source of short, medium and long-term cost growths.
2. Mapping to a central workflow model for process automation and management purposes.
3. Using a customer and billing model as the basis for web portal automation, to ensure efficient secure technology services.

1.8 Vehicle owner/drivers

Vehicle owner/drivers require web access to tariff calculations, billing and actual journey information.

If the web self-service components are implemented correctly, there are opportunities to engage vehicle owner/drivers in the provision of essential information such as transport works, and carbon emission information.

It is also an opportunity to involve this sector of the community in public transport and environmental policy.

1.9 Solution Characteristics

Network:

LAN, WAN and wireless network high speed capability is at the basis of the communications for the road pricing capability. Secure data centre hosting capability with failover and resilience using a mirrored data centre. (See network deployment architecture.)

Web and Application Servers:

Optimally configured web and application servers with the smallest footprint for firewalls and demilitarized zones possible consistent with secure best performance.

Security:
A security solution for application level security e.g.

- access management
- identity management

Network security as per corporate security policy

This solution has to integrate vehicle tracking data collection with web self-service, rating and billing engines, and the infrastructure has to encompass both data and application integration.

An application services platform has to provide common infrastructure services for security, workflow, rating, billing, customer self-service and other application interfaces. This platform has to supply integration services such as event handling, queuing and monitoring of long-running communications, as well as to perform application protocol transformations. This platform has to utilise existing applications and integration where feasible, and in addition grow in the direction of common service interfaces and reusable processes.

The IP gateway has to integrate with the telco network gateway. The gateway servers have to forward collected data to appropriate mediation engines.

1.10 The Technology

Standard industrial strength software, firmware, hardware and network to current best practice and architecture are required to meet functional and non-functional business requirements.

The technology platform has to support application integration, data integration, and high traffic web access, and consequently enterprise content management and delivery.

Hardware and hosting infrastructure has to be monitored and managed, highly resilient and able to scale on demand.

1.11 The Resources

Some of the infrastructure cost categories are

1. Architecture and solution design to meet functional and non-functional requirements provided by business
2. Programme and project management costs
3. Server hardware configuration and design
4. Systems monitoring, management and maintenance
5. Data storage configuration, disk and tape SANs, backup and recovery
6. Application infrastructure services
    a. Device services
    b. Security access and identity services
    c. Portal services
    d. Workflow services
    e. Web/Application platform services
    f. Integration and messaging services included B2B
    g. Data services
7. Network architecture and design and internal and external component costs
8. Telco gateway architecture and infrastructure costs.
9. Solution build, test, pre-production and production for internally managed application components.

The cost dynamics have to consider the following factors:

1. The economics and viability of selecting technology services
2. Strategic evaluation and development of migration path for any re-use of current functionality and the need to implement updated technology applications
3. Choice of technology services with a view to evolution towards autonomous (stand-alone) and autonomic(self-describing) technology services

The estimation process needs to consider the quality and economics of existing technology and vendor offerings within the context of corporate technology directions.

The estimation process has to be collaborative and transparent and involve network, infrastructure, architectural resources, and the processes have to be internally consistent.

1.12 The People

The key skills are

Solution and Delivery Architecture – ability to deliver broad solution architecture addressing functional and non-functional requirements. The solution architecture includes solution specification and implementation checklists. The solution architecture for all technology services have to be technology independent of current implementation vendor specifics, and legacy systems.

Logical Design – UML and logical design skills – provides logical design of solution components.

Information Design – Logical and physical data modeling skills, able to implement information models including web content delivery models

Business Process Management – Monitor and manage the application of technology services to accessible, clearly identified and catalogued business processes.

Hosting and Network Management - Hosting infrastructure and network utilization and resource determination.

Project and Programme Management – ability to understand the strategic overview and to monitor the schedule. Ability to manage complex parallel processes, and to manage communication amongst all interested parties

1.13 Key Lessons from the Industry

Scalability and flexibility of technology infrastructure are very important to deal with this kind of data volumes and web access.

Support from the top level, and communication between major stakeholders is essential.

In addition it is particularly important to deliver a billing system capable of flexible discounts, not only during rating but also at billing time.

2 OUTLINE SOLUTION

2.1 Business Objectives

The major objectives are

- to enable distances driven to be quoted, collected, rated, billed and invoiced from data collected by wireless network satellite vehicle tracking
- to enable customers to view their rated journeys in as near to real-time as possible
- To enable flexible web self-service over a variety of interaction channels on cost-effective infrastructure for increasing scale of in-vehicle devices to planned timescales with 24 x 7 supports.

2.2 Background

This document provides an overview of the anticipated technical architecture options available for around 100,000 devices. It is based upon the premise of sensible re-use of the current implementation in view of the strategic directions for road pricing.
The main issues are those around scalability of components, and use of technology that may not be flexible enough for clearly apparent and anticipated technology directions of change.

Cost estimates have to be based on a preliminary understanding of the requirements and projected usage. These estimates may then be used as a basis for the detailed technical architecture, which will be produced during the design stage of the work packages.

2.3 Processes

An outline of processes involved in completing the infrastructure architecture is as follows:

1. Analysis of prioritised functional and non-functional business requirements
2. Determination of strategy for reuse of current implementation in view of target infrastructure architecture based on scalability assessment, capacity planning, and planned infrastructure changes
3. Determination of a flexible programme of work to meet possible timescales. Ability to adapt to contingencies encountered in setting up large data volume collections for the first time.

2.4 Deliverables

A pilot implementation is recommended to test the areas of greatest technology challenge. The desired time-frame for implementation is around 6 months. To achieve this, the method of working has to be agile, and just-in-time, within the context of team collaboration, with a loop back to the business to achieve flexibility in the phasing of requirements. Provided there is co-operation amongst stakeholders, and a strategic programme plan is adhered to, the deployment is achievable within 6 months, allowing flexibility in the way architecture, design and construction fit together. A concrete schedule for construction testing and maintenance is however mandatory.

Architecture, Design and Programme Delivery:

1. Solution architecture addressing business processes and non-functional requirements
2. Logical architecture of functional requirements including information architecture
3. Infrastructure architecture, software, firmware, hardware, and network.
4. Detailed technical design documents for secured platform, hosting and network infrastructure.
5. Implementation work packages and schedules
6. Programme and project plans schedules and change management processes

2.5 Technical Solution Outline

The basic solution is very broadly outlined here.

The technical solution involves the following pre-requisites

1. Cost-effective infrastructure 24x7 fully maintained and supported over 5 years.
2. Early and ongoing liaison with device providers, and telco network providers to ensure anticipation and resolution of potential issues.

3. SLAs for construction and maintenance to be established early in parallel with infrastructure architecture in order to establish appropriate time frames for responses.
4. Functionality to be assessed over pilot and full deployment phases,
5. As a result of the architectural assessment, solution options by a minimum of two vendors
6. An overall solution architecture is to be developed for PAYD, in addition to solution architectures for each component, based on a standard process.
7. A pre-requisite for overall and individual solution architectures to be completed functional and non-functional requirements.
8. Tactical and strategic elements of the solution are to be clearly identified and tactical components to be signed off by business owners.
9. Programme co-ordination to be performed round a steering group of business, programme management, architecture and builders, with invited expertise as appropriate right through the project lifecycle.
10. In view of the tight time constraints, the business accountability, programme planning, architecture, and technical development to be an iterative process based on regular steering group meetings where all parties can openly raise, discuss and deal with business, programme and technical issues. This is to be done with solution specifications and programme schedules being subject to a change management process.

Once the programme framework and solution architecture have been aligned with the above pre-requisites, the following steps complete the design, construction and on-going maintenance and development.

1. Logical definition of processes
2. Design of solution components
3. Design of network solution
4. Change management programme
5. Construction
6. Testing
7. Maintenance

2.6 Risks

The major risk lie in those parts of the solution where there are external dependencies, i.e. telco wireless network gateway, configuration of platform and infrastructure for mediation and storage of large data volumes, and larger scale integrated web self-service access by customers.

The major mitigation strategy is to evaluate all proposed technology service providers against specified service levels, in service level agreements. The second part of this strategy is to performance manage and monitor end-to-end across the infrastructure.

3 CONCLUSION

The reasons for strategic planning and engaging in solution architecture and well managed delivery processes are to avoid the common pitfalls e.g.

1. Having to rework the technology to accommodate growth
2. Cost escalation because of technology service work arounds
3. Less than robust technology because of inadequate infrastructure

It is recommended that pay-as-you-drive road pricing be tested with a pilot sample, and then implemented in phases in a strategic way to complement the prioritised business requirements, and the technology maturity of the organization.

This implies a collaboration with the corporate customer to complete:

1. Formal definition of business processes in addition to functional, non-functional requirements
2. Formal definition of service levels to agreed business and technical standards.
3. Formal definition of workflow and roles for purposes of security and web self service access

These simple steps will ensure that pay-as-you-drive road pricing progresses along a path towards the strategic goals, at a sensible pace of implementation, with a secure foundation and acceptance by all stakeholders.