OUTSOURCING OF COMMUNICATIONS NETWORKS

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Outsourcing of services is a concept that has the virtues of political correctness and fashion. It is certainly not a new concept but outsourcing has become a popular answer to all manner of corporate ills. Its current significance is perhaps not unrelated to some of the spectacular corporate failures of the 1980s when short term gains were the objective of many an entrepreneur. The current reaction appears to be an emphasis on "core business" activities, with those activities that are not considered essential to the core business being "outsourced".

Some would argue that communications are not core business for railways and that they should have been outsourced long ago. Others will argue that communications are the very life blood of a modern railway -- as integral a part of the operation as the track, locomotives, rolling stock and signals.

In this paper we consider the role of communications in railway operations, the impact of historical developments, the impact of developing technology and the impact of legislation on railway communications. There are some areas where outsourcing is a natural and obvious step, some areas where outsourcing would achieve nothing and others where outsourcing has been in place for a long time. The common characteristic is that they provide communications for trains that move on steel wheels on steel tracks.

History repeats itself

(The historic information in this section is based on the History of NSW Railways by James Dargan entitled "Morse to Micro", published by the author in 1988).

The first electric telegraph in Australia was installed between Melbourne and Williamstown, opening on 1 March 1854. Following this a system was installed between Port Adelaide and Adelaide.

Such new fangled ideas were certainly not welcome in New South Wales. The Governor in Chief expressed his opposition to the introduction of the of telegraph (July 1855):

> *"in the present state of the colony there does not appear to be any such demand for the adoption of these rapid means of conveying intelligence, as would justify an application to the council for its sanction to the large outlay which would be required for the establishment of an electric telegraph on the most economical principle".*

Despite such clear opposition, the first electric telegraph was installed in Sydney within two years. It connected between South Head Lighthouse, the Sydney Post Office, the Royal Exchange and the Redfern railway terminus. The person responsible for its installation was Captain Martindale who was the Undersecretary for Public Works, Commissioner for Main Roads, Commissioner for Railways and Superintendent of Electric Telegraphs. He reported to the Legislative Assembly on 27 May 1887 that:

> *"The advantage to the railway department in meeting the wants, and ensuring the safety, of the public using the rail will be very great, and the more so as single lines extend. Indeed it is barely safe to operate a single line of the railway without a telegraph.*

The telegraph was extended rapidly, one branch reaching Liverpool by October of that year. The NSW Government decided that the line should be open to the general public and on 26 January 1858 made the following proclamation:

> **RAILWAY DEPARTMENT SYDNEY**
> **OPENING OF THE ELECTRIC TELEGRAPH**
>
> Notice is hereby given that on and after the 26th instant, the line of electric telegraph between Sydney and Liverpool, and Sydney and South Head, will by order of the Government be open to the public for the transmission of messages...

During the next year the telegraph was extended, linking with the developments in Victoria and South Australia. The extension of the Northern line to Brisbane in 1861 completed the connection of the Eastern capitals.

Many telegraph offices were established on railway stations and the telegraph was a joint service shared by the railways and the public, the Post Office being a separate entity. A NSW Government statement in 1859 prescribes some commercial arrangements:

> *"On the railway lines an arrangement has been made that so far as the [telegraph] line extends along the railways, accommodation shall be provided for the telegraph clerks on the railway stations and all messages for the department on railway business shall be sent free. The telegraph department however taking all receipts for public telegrams sent by railway wire".*

While not exactly core business, the public communications infrastructure was a railway responsibility. The operators of the service were employed by another department but were accommodated on railway property and provided an outsourced facility for the railway. (The arrangements were not very different from some of current proposals.)

The outsourced telegraph operations continued in NSW until around 1876 when the NSW Electric Telegraph was absorbed by the NSW Post Office. However, there was a complicated transition and the railways and post office have continued to lease each other's wires for over one hundred years.

The commercial arrangements changed over the years, as did the relative proportions of the leased services. By 1932 there were 3,823 miles of NSW railway wire on PMG poles and only 2,316 miles of PMG wire on railway pole lines. The railway administration was very conscious of the costs involved and by 1947 had reversed the imbalance to 1,006 miles on PMG poles, while the PMG had 2,953 miles on railway poles.

Automatic Telephony

The railway continued to be at the forefront of communication development, with the second automatic telephone exchange in Australia being installed in a NSW railway office in 1913. (The first was a Strowger exchange that was installed in Geelong the previous year.) Many more automatic exchanges were installed in railway offices and the railways applied the developments that were being made in other areas. The public communications networks were jealously guarded by the PMG and interconnection to the public network was subject to strict regulations that were developed and enforced by the PMG.

For many years the railway networks had provided railway users with direct access to the public network (dial "0" for an outside line). The reverse was not the case. PMG engineers took the view that they could not guarantee a good grade of transmission to their customer once the call entered railway equipment that was not under PMG control. The PMG did not approve the installation of direct indial facilities until 1947 (after much high level negotiation).

Public access to railway systems continues to be regulated and at present the railways can only offer facilities to the authorised carriers. This situation will change dramatically in 1997 when many of the current regulations are lifted.

121 years to turn the full circle!

Safety, System Integrity and the Seven Layer Model

Safety of train operation has long been cited as a reason for railway communication systems to be directly operated by the railways. In 1901 the Commonwealth Constitution gave the Post Master General a monopoly over all communications in Australia but granted specific exemption to State railway systems in the interests of train safety. Railways were permitted to install and maintain their own communications, but only on railway property.

The simple systems that were employed at the turn of the century relied upon the physical construction of the bearer for their integrity. Track circuits and safeworking systems were directly connected from end to end and identified by circuit. Incorrect connection of different circuits could not readily be detected so there was great emphasis on the responsibility of staff to check and recheck each connection. The concept of having someone from outside the railway making such connections and rearrangements was unthinkable -- the consequences of inadvertent error would be too severe.

While pole routes were shared and some railway wires were carried on PMG poles, safeworking circuits were always confined to railway pole routes. Some of the safeworking and signalling systems used voltages that could not be

contemplated on telephone networks. (For example, two hundred Volt DC pulses were used on the Western Electric systems for telemetry and signalling functions.)

The limitation to railway operated circuits was a requirement of the technology available at the time. The system design assumed and indeed required a fixed connection and mapping from one end to the other. The majority of the railway systems used direct current signalling and were vulnerable to changes in polarity and connection of the lines. This situation continues with the electric staff systems that need a direct current connection between pairs of machines.

The development of transmission networks for railway signalling systems has been limited by their reliance on physical connections. Carrier equipment has been in use in railways for communications systems since the 1930s. Its use for signalling systems has been affected by the bandwidth of each carrier channel being restricted to between 300 Hz and 3400 Hz. With no direct current connection, the operation of functions such as polarity reversal and pulsing direct current was made more difficult and signalling systems continued to use physical circuits. (It is interesting that the telephony systems also used DC signalling over carrier systems through the "E&M" facilities which provided an on/off indication in each direction of transmission. The E&M leads were used for telephone dialling and call signalling in most telephony systems, being superseded only when fully digital carrier systems became available).

System Integrity

Railway communications and signalling systems are required to operate reliably and accurately. The operation depends in part on the integrity of the system. In the simpler systems (and even in many of the current systems) this requires a procedural method of ensuring that the end points of the system are correctly and continuously connected. Some systems have alarm mechanisms built into them that identify interruptions to the physical circuit. (It is assumed that the circuit that was interrupted could have been corrupted by incorrect re-connection.) Any system that connects through a distribution frame or patch panel is vulnerable to this type of corruption.

Switched circuits can not be considered if the physical connection is essential to the system integrity. A switched system can not be guaranteed to always make the correct connection and the connection can not be guaranteed to be maintained. This places a severe limitation on the flexibility of service provision as the only acceptable communications system is one that is physically located on the railway property and is maintained by persons who are competent with the particular system.

Alternative Approaches

The alternative is to develop a system that does not rely on any particular physical connection for its integrity and operation. The more sophisticated telemetry systems (and of course the electronic telephony systems) were probably the first railway systems to take this approach. Each device in the system was given an identity code which it transmitted in every communication with the controlling device or devices. The system integrity could then be checked on every exchange of data and a means had been created to test the system unambiguously at any instant.

Protocols and addressing systems have rapidly developed and are essential elements of systems that we take for granted today -- the Local Area Network (LAN) and the cellular telephone are examples of such systems. The LAN usually has fixed connections but addresses packets of information to particular devices that may be physically connected anywhere on the network. The cellular telephone has no fixed connection and random location within the network but the protocols identify the terminal and transfer voice and data to the telephone as required.

The operation of communications systems such as the LAN and cellular telephone have been facilitated by the disciplined allocation of protocols and functions to particular layers of a structured transport and communication system. The OSI seven layer model is a well-known example of a formally defined approach to system design that separates the functions of physical connection and information transport from the unique functions of the system. If this approach is taken in system design, the system can be made to operate with safety and integrity over a variety of communications systems.

Outsourcing the Service

Outsourcing is often seen as handing over a set of activities to an external organisation. The external organisation then takes responsibility for performing those activities and deals with all related supply and resource issues. The activities may consist of providing a complete service (for example, the supply of locomotives and locomotive maintenance on a "power by the hour" basis). Alternatively, it may be limited to operating or maintaining an asset on behalf of the principal (for example, contract maintenance of track or locomotives).

These approaches have been applied to the provision and maintenance of track, locomotives, rolling stock, signalling and communications. However, in the most cases, the communications systems have continued to be railway owned systems on railway land that have been maintained by a contractor. The table below provides a rough indication of the approaches which major Australian railways have taken. (The information in the table is based on general knowledge and public information and may not represent current railway intentions.) For the purposes of this analysis we have treated metropolitan railways as separate operations from the relevant state-wide operator and have included the major iron-ore railways. One tick has been used for each applicable entry -- some operators will have ticks in several columns as different portions of the railway infrastructure are handled differently.

Facility	Service or Facility Outsourced	Maintenance or Operation Outsourced	Railway Operated and Maintained	Service or Facility supplied to Others
PABX Network	✓	✓✓	✓✓✓✓✓✓✓✓✓	
Data Network	✓	✓✓	✓✓✓✓✓✓✓✓✓	
Voice and Data Links	✓✓✓✓✓✓	✓	✓✓✓✓✓✓✓	
Train Control Radio	✓✓✓	✓✓✓	✓✓✓✓✓✓✓✓	
Mobile Radio	✓✓✓✓✓✓	✓✓	✓✓✓✓✓	
Communication Sites	✓✓	✓✓	✓✓✓✓✓✓	✓✓

Table 1 Communications Outsourcing in Australian Railways

There is a clear predominance of railway operated and maintained systems. Voice and data links between sites are leased from carriers in a number of instances, either as individual circuits or as complete systems. Radio communication between Train Control and trains, long considered to be an essential railway facility, is now completely maintained by contractors on a number of railways. Some other railway operators have moved or are moving to the use of public communications systems such as trunked radio networks for this facility. The trunked radio systems are increasingly used for railway maintenance services. Interestingly, very few operators have sought to earn revenue from the communications sites and infrastructure that they have established. Even under the existing communications regulations there is ample scope for "inverse outsourcing" in this area.

The PSTN as a Communications Medium

The Public Switched Telephone Network (PSTN) has traditionally been avoided for railway communications. There have been some very good reasons to avoid the use of the PSTN in the past, most of which were related to operating cost. However, the continuing rationalisation of railway lines and the reduction in staff levels away from the main operating centres have made the PSTN an attractive option.

Some railway operators have installed PSTN connected telephones at staff huts and other safe working locations to avoid the cost of maintaining pole lines on lightly trafficked lines. Other operators are using the public mobile telephone services for train control and reporting and several operators intend to use the mobile satellite network for safeworking communications. This is outsourcing taken to the limit, the entire facility being externally provided. The cost structure changes in this case from one of capital investment and fixed maintenance cost, regardless of the train traffic, to one based directly on usage.

The PSTN and Route Diversity

The PSTN has been designed as a fault tolerant system. Only a small portion of the PSTN link is dedicated to the connecting device. This portion is the "local loop" -- the connection between the terminal device and the local exchange. Apart from a small set of line interface equipment, the telephone network consists of multiple devices and connection paths that provide a high level of redundancy. All this comes with every PSTN connection. A traditional track side communication system does not provide route diversity and may have many common points of failure. (Some railway systems have a ring connection or PSTN backup link to provide some redundancy).

The PSTN has developed in capacity and reliability and offers digital connection from end to end (ISDN). Perhaps it is time to think of the PSTN as a low cost, fault tolerant solution to intermittent communication.

A Matter of Finance

Previous Investment Limits Options

Most railway communication systems represent significant investment of capital. The investment that has been made becomes a constraint on the adoption of new technology, even when the new technology may offer a short pay back period. There are several railway communication systems in service today which could be more effectively replaced by an outsourced service but are retained because of the existing investment. As the rate of technological change increases the communications systems will have shorter operating lives and very substantial investment will be required to keep up with the technology. Since the railways' competitors will certainly be using current technology, the railway operators will not be able to compete with outdated equipment. There appears to be good reason for carefully considering the use of the services of carriers where this is practical.

Outsourced Maintenance

Outsourced maintenance has been adopted by the railways in many skill areas, a number of operators outsourcing all of the communications maintenance. The financial benefits of outsourced maintenance of railway communications systems have not been made public and will depend on a number of factors. These factors certainly include the geographic location of the railway, the traffic levels and the response time required for faults on the particular system.

It is important that the outsourcing arrangements allow for genuine competition in tendering for the maintenance contracts. An example from outside the railway industry is the National Transmission Agency, a government agency responsible for the provision and maintenance of the ABC and SBS radio and television transmitters throughout Australia. The National Transmission Agency is responsible for 542 transmitting sites and 1123 transmitters. It has always used an outsourced maintenance approach but has recently reorganised the contracting strategy to broaden the market. The result has been a reduction in maintenance costs of $20 million per annum with no reduction in standards of performance or response to faults. The National Transmission Agency covers a larger part of Australia than the railway networks and has equipment in locations just as remote as any railway system.

Inverse outsourcing

One could hardly conclude a discussion of outsourced railway communications without considering the logical alternative: "inverse outsourcing." As we noted at the outset, railways were the original service providers for public communications and the legislative changes will again open the door to this option. A few operators are actively investigating this option.

There are other options, short of becoming a telecommunications carrier. The railway easement and communications sites can be made available for use by carriers. This may be done on a straight access charge basis or in return for the provision of a service to the railway. The railway can carry traffic for other government agencies and form a part of an integrated government network. Alternatively, parts of the railway communications systems may be let to the carriers for them to resell to their customers -- this has been done consistently since the earliest days.

Summary

Railway operators have moved from being communications carriers to being operators of private communication systems. The changes in technology and in the business environment have caused railway operators to seek alternative solutions. There is now an increasing need for outsourced services, such as the PSTN, mobile telephone and trunked radio.

The adoption of outsourcing and the use of public networks have been limited by the design of a range of railway communication and signalling systems. These systems have relied on their physical connection to ensure the integrity of the overall system. The adoption of structured system design and comprehensive communication protocols have overcome these problems and communications systems can now be designed to operate over virtually any communications network.

Outsourced maintenance is widely used and offers many benefits for the operators, although most railway systems still require specialised skills and qualifications for the maintainers. These requirements limit the number of potential suppliers and therefore limit the economies that may be achieved.

The legislative changes that are taking place provide the railway operators with an opportunity to engage in "inverse outsourcing." Railways with extensive communications systems could provide the communications system services that they operate to carriers and to the public and gain a return on their investment.