Distributed Architecture for Radio Systems

White Paper

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simoco

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Introduction

The benefits of reliable communications are well understood by operators of business and mission critical radio networks: as are the consequences should those networks fail to perform. To public safety, utility, natural resources, government and transportation providers the world over, radio is a key component in ensuring that operations are safe and effective.

The distributed architecture model is well suited to the deployment of mission and business critical radio systems. Its key benefits of simplicity, reliability, scalability and cost effectiveness are recognised by telecommunications users worldwide.

IP is the ideal technology to deliver these benefits. By following a set of clearly defined rules, system architects can design high capacity, secure, resilient radio communications networks required to support misson critical operations.

Given the significance of radio in so many working environments it is perhaps surprising that fully IP connected radio systems are not more common. We employ IP connectivity to support our businesses every day to conduct everything from a simple telephone call through to secure financial transactions. In our private lives personal mobile devices, utility services and even household appliances are nodes in vast IP connected communications networks.

But often it seems, when it comes to mobile radio, the line is drawn. Voice over IP for your desk phone? Of course. Corporate LAN for e-mail and business systems? How else? But for licensed mobile radio IP some argue is a step too far .

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Key points

When considering the next evolution of radio system infrastructure, Simoco's early thinking was influenced by the rapid advances in IP based telecommunications networks at that time. Three key points stood out;

- the advantages of using a standard hardware platform with functionality controlled by software
- the potential of well designed TCP/IP networks to remove single points of failure
- a realisation that Voice over IP was rapidly replacing fixed line circuits

When combined, these elements - already in everyday use in other systems - were ideal for inter-site radio links.

IP Networks: is there a Downside?

Is it the Internet?

Whilst the communications technology and protocols used are the same, a private IP network for radio communications systems differs from those of the Internet. The main distinction being that the devices on a private IP network are only visible to each other, whilst all devices on the Internet are potentially visible to each other.

What about Reliability?

We use IP networks, directly or indirectly for most of our voice and data communications. The flow control mechanism inherent within TCP/IP ensures the reliable flow of data and manages its movement between devices. Monitoring and dynamically aligning transmission and reception to ensure effective transfer.

Is Voice Quality Affected?

Within IP networks all traffic is data, voice is simply divided into packets for transmission in the same way as all other information. Bandwidth however is an important factor, and therefore there is a trade off between data compression to reduce the bandwidth required and maintaining voice quality.

The good news though is that the digital nature of IP networks means that there is no scope for the network to introduce noise, no requirement to adjust line levels or

match impedances. Therefore the data compression can be controlled to suit the needs of the customer and voice quality remains consistent regardless of the physical backbone and geographical distances. It reaches its destination through IP addressing, no matter where on the network that address is.

To summarise, the use of IP enables voice quality to be maintained consistently across the network whereas other backhaul technologies can introduce voice degradation and can require complex engineering to setup and maintain.

compared with most IP networks which are designed to deliver high bandwidth data. It is important that the IP backbone is designed to support the requirements of the radio system but contention within the IP network is rarely an issue.

Arguments

Switch based architecture (Fig. 1)

Switch based architecture is a logical concept that employs a central switching unit to manage the interconnections between two or more nodes.

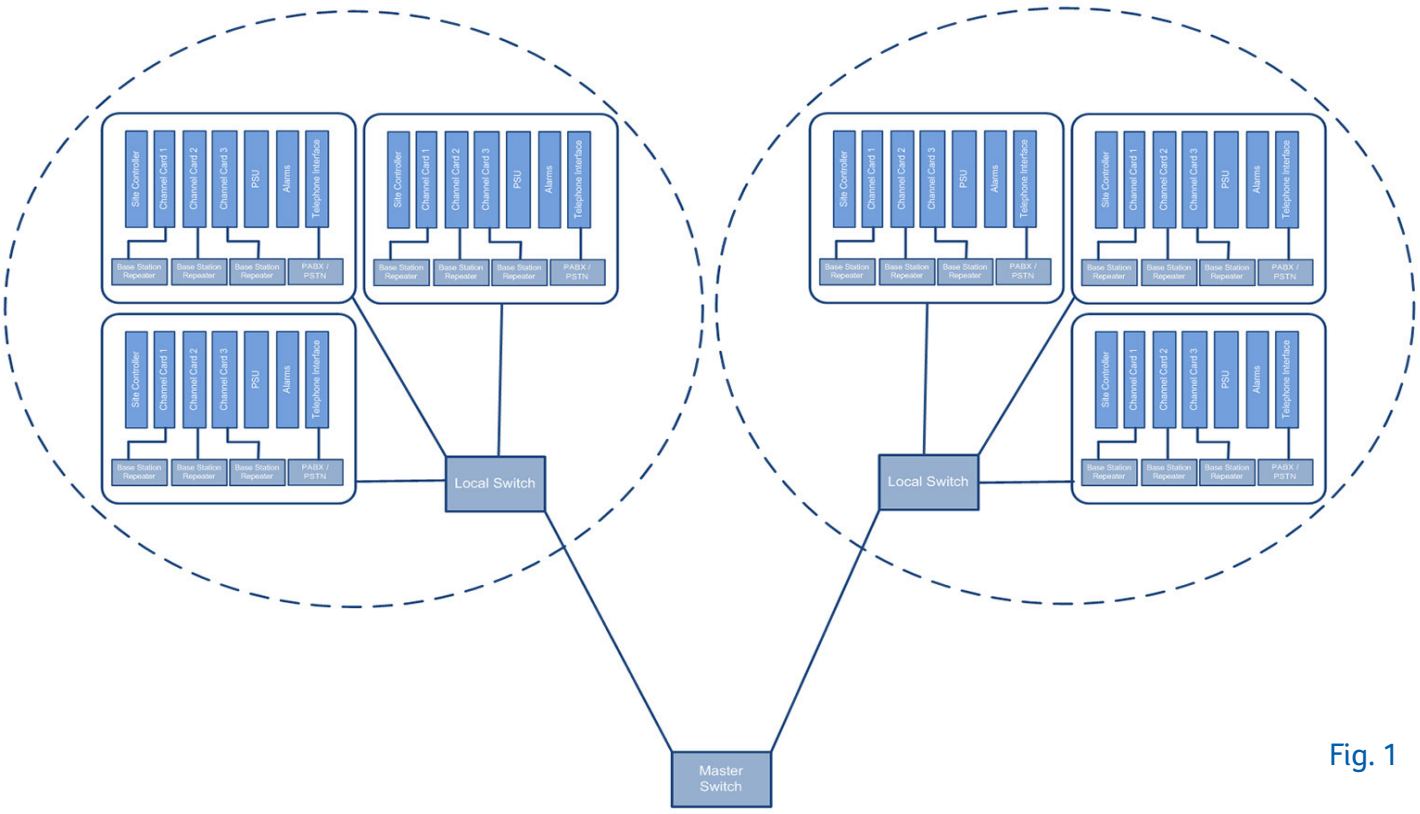


Fig. 1

Is it Secure?

Whilst no network can be 100% secure, due to the requirements driven through the widespread adoption of IP networks from industries such as finance, public safety and government security, IP networks are the most secure backbones available today when implemented with the necessary features.

Any private network should include a correctly implemented and maintained security policy. Router security features should be employed at all sub-net boundaries, where parts of the network are shared with public Generic Routing Encapsulation (GRE) tunnels that can be employed. When remote access is required then a secure VPN can be used.

What about Contention?

Radio systems are designed to be frequency efficient with regulators around the world keen to see channel bandwidths reduce with the advent on new TDMA technologies such as DMR and P25 Phase II. As a result, radio systems are a narrow bandwidth proposition

When applied to multi-site radio systems, a node is a radio site generally comprising a series of base stations with a site controller exchanging control data with a central switch. The site controller brings its base stations into calls as needed and, where inter-site calling is required, each base station has a dedicated landline for call audio. The central switch is then responsible for routing call audio to dispatching, telephone extensions or other sites.

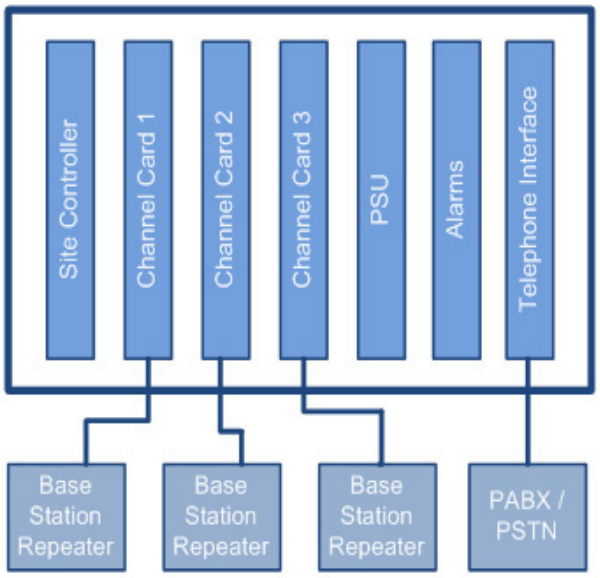
There are several drawbacks to this architecture:

1. The central switch is vital, if it stops working then no inter-site calls can take place. It is possible to double-up by adding a second, redundant switch at each central node but this also doubles the cost. In addition some means of automatically managing the changeover between switches is required.

2. Complex radio site equipment is required to interface base stations with the site controller and audio connections. This series of discrete units is costly and setup requires a high degree of technical expertise.

Furthermore a greater number of separate components increases the size and cost of the spares holding.

3. Having a dedicated landline for each base station means providing a lot of resource just in case it is needed.



Linking sites with IP

As IP based telecommunications networks became more prevalent, it was not always possible to get fixed telecommunications circuits at all sites. An alternative was available in the form of IP based circuits and some manufacturers took advantage of this by introducing IP to serial/analogue converters that allowed current radio infrastructures to utilise IP based inter-site links.

The diagram below shows how some of the links between radio sites started to be provided by IP backhaul rather than dedicated leased lines. Whilst this started to move radio systems onto IP networks it had the disadvantages of the additional cost of converter hardware and more significantly it retains all of the disadvantages of switched based architecture.

Distributed Architecture (Simoco Model)

The distributed radio system architecture employed by Simoco emerged from a critical review of the switch based system and desire to incorporate advances in IP based telecommunications into its radio infrastructure products.

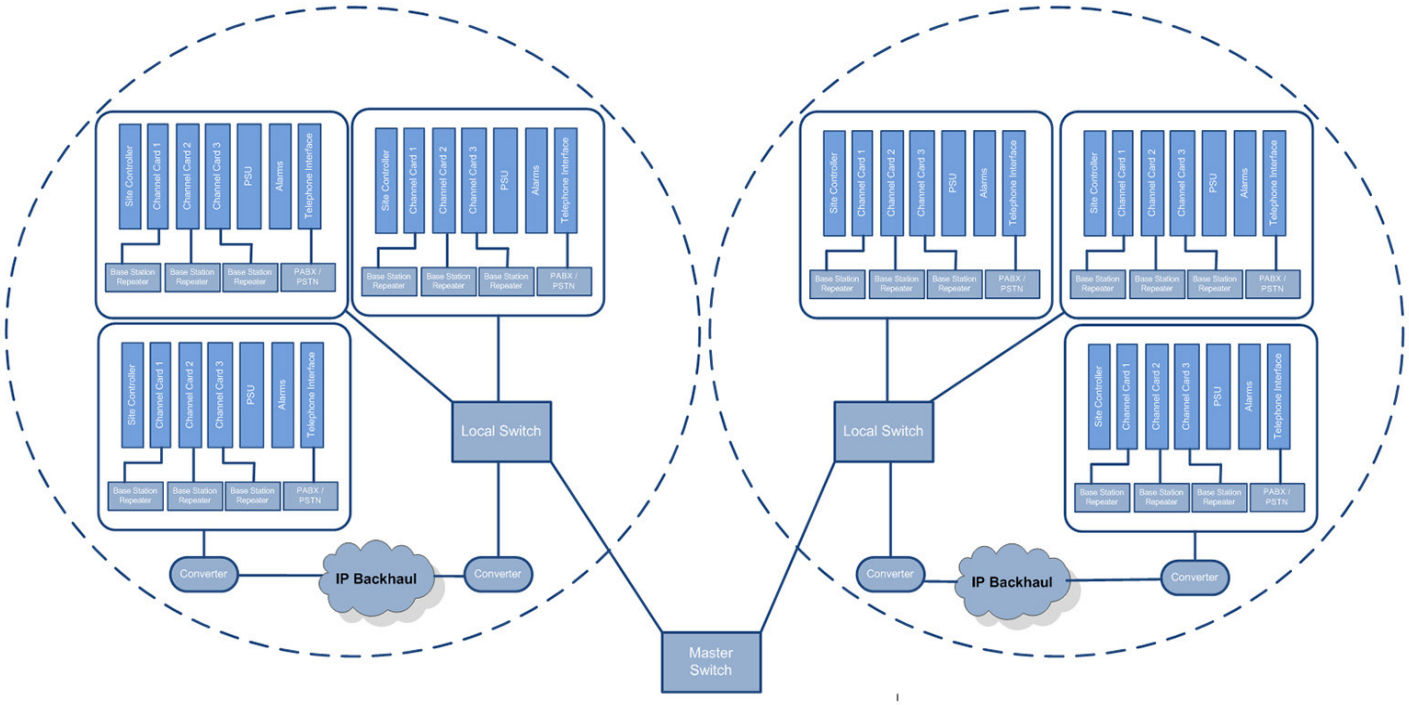
Before the benefits of the architecture itself can be realised it is first necessary to develop equipment capable of operating on IP based networks.

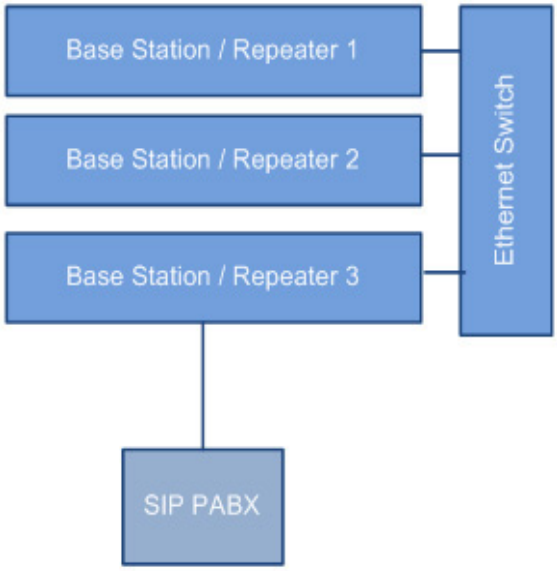
- Commonly available processors have sufficient capacity to take on the central switch function and come at a low enough cost to enable them to be used on every base station.

- Digital Signal Processing (DSP) techniques replaced custom Integrated Circuits lowering costs and ensuring that current and future signalling techniques could be supported. This also enabled single PCBs to be designed that were capable of combining the functionality found in the site controller, channel card, alarms card, telephony card into a single repeater.

- Software configurable Input/Output, for integration with other site equipment, was introduced and industry standard VoIP and telephony protocols were adopted to enable an all IP intelligent Base Station to provide all the functions of the previous generation of switch based systems.

When combined with radio frequency modules this creates a highly flexible hardware platform that can be





configured to meet the needs of a large number of radio system users.

The integration of all of these functions with into a single unit results in a base station with all the capabilities of site controller within it. Since all units are identical then any of them can manage the radio site and greatly reduces the risk to the system should any unit fail. When this is deployed within a well designed IP network that has the necessary bandwidth, quality of service and switching capacity to support mission critical communications, it results in a fully distributed architecture and extremely resilient.

Need to redraw above and remove Ethernet switches which take wind out of the no single point of failure.

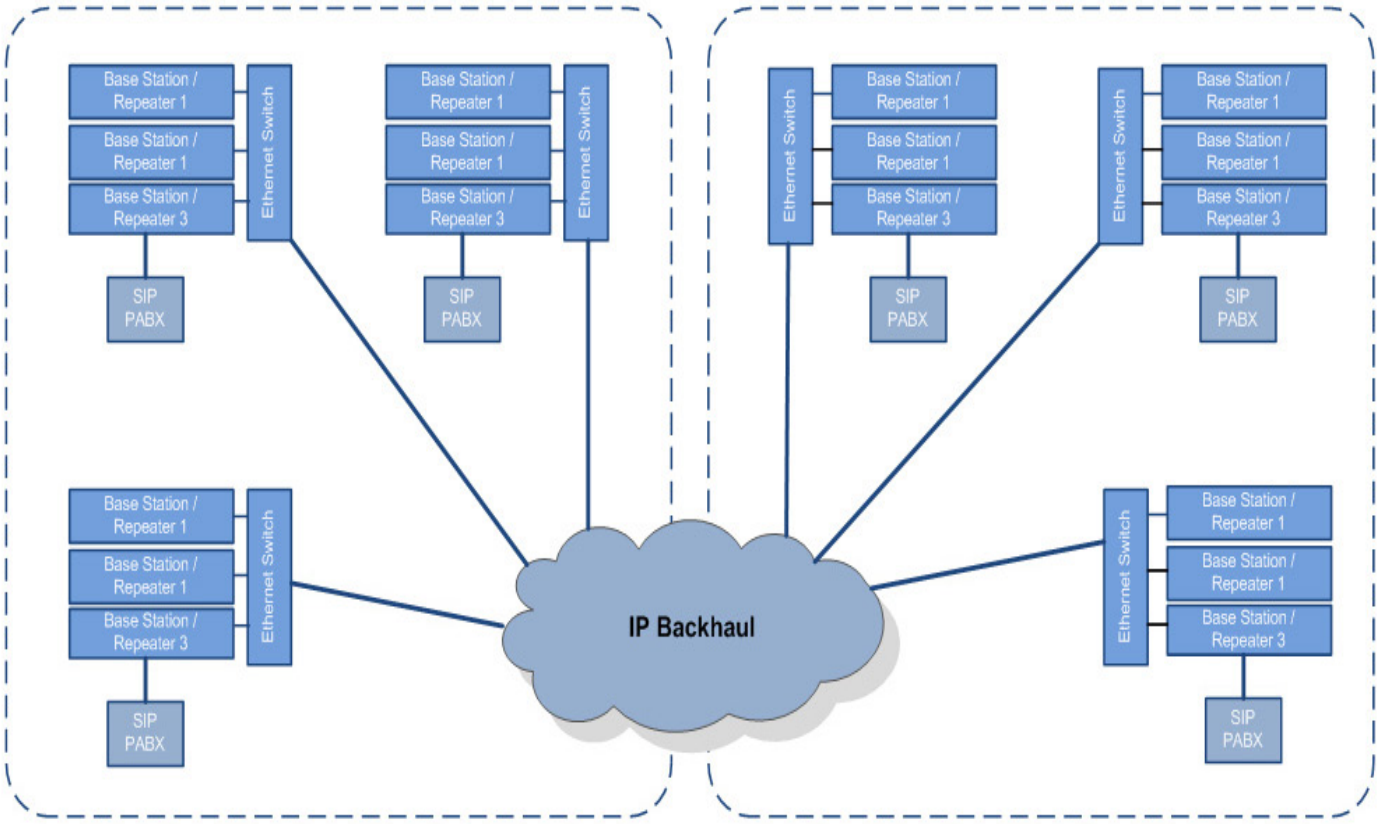
Advantages

The resulting system has several key advantages;

• No single point of failure – Central switch functionality has been migrated from hardware to software. This "virtual switch" can reside on any base station. Should the unit acting as the switch fail then the remaining base stations arbitrate and one becomes the new virtual switch assuming control of the system.

• Simplification of site equipment – Each base station is identical. Site controller, channel controller, telephone interconnection, alarm generator and radio base station are all contained within the same unit. Spare equipment holding is lowered and sophisticated management software reduces complication and staff training requirements. Ethernet connectivity and IP addressing greatly enhance functionality and enable the unit to operate on IP networks.

• Voice Over IP makes effective use of IP backhaul not only allowing audio packets to be automatically routed around any issues within the backhaul network, but also by also enabling sites and management applications to interface at any point on the IP network.



Radio Technologies

Whatever the merits of dedicated telecommunications links were a decade ago, they have now been overtaken by advances in the design and availability of IP based networks. The result is IP backhaul networks which are provide higher bandwidth and more resilience but at a lower cost.

IP connected telecommunications networks are becoming common in all sectors and today's radio standards are well positioned to exploit them. APCO P25, Tetra, NXDN and DMR are all able to employ IP networks for interconnection. These open standards, each with their common air interface, are the core communications technologies for many of the world's mission and business critical radio systems.

Manufacturers moving away from the conventional switch based system model can exploit the principles of distributed architecture and produce reliable radio systems that deliver greater benefits then digital radio alone.

Summary

By adopting a distributed architecture for IP connected radio systems approach it is possible realise the following benefits;

Simplicity

A single intelligent base station that replaces a number of discreet system components significantly reduces the complexity of the system, making it easier to deploy and maintain.

Scalability

The protocols and hardware used in IP networks allow them to be scaled up to meet changes in system requirements. This is matched by a distributed radio system architecture which, due to its switchless design, is able to be ultimately scalable.

Resilience

Good system design combined with the inherent reliability of IP and the right equipment enables the deployment of robust, fault tolerant networks without the need to duplicate high cost hardware equipment.

Open Standards

Use of IP connectivity means the same principles apply anywhere in the world and system architects are free to choose whatever vendor equipment they wish to create a distributed architecture radio system.

Security

By applying IP security at the boundaries of radio system sub-nets, implementing network security policies and maintaining control over remote access is made easier and more effective. The security of an IP based radio network can be equal to or, it might be argued, greater than those deployed using discreet telecommunications circuits.

Management

Use of a single protocol throughout the system architecture for both core process and radio system operation permits control data, voice traffic and statistical data to share the same network.

One notable point being that IP networks allow rapid and reliable software updates meaning that new features can be introduced without service visits.

Cost

Global adoption of IP networks and the transition of central switching from dedicated hardware unit to software function have driven down the cost of deploying and maintaining a distributed architecture radio system. Having all of the above elements combined into a robust, high availability communications system gives radio users peace of mind, allowing them to focus on their operational tasks without worrying about their radio system.

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Conclusion

Creating a true distributed architecture radio system involves more than simply linking sites with IP. To be able to take full advantage of its properties requires the use of generic and identical system components resulting in radio systems that are simpler and significantly more resilient than their switch based predecessors whilst at the same time holding down cost.

A genuinely distributed radio system has no central component(s) and therefore failure of any piece of equipment within the network will result in the overall system continuing to operate seamlessly. The emergence of IP backhaul has enabled this change in approach to happen and it the perfect vehicle to provide secure and reliable inter-connections to radio sites.

About Simoco: Connections count and, with a history of over 70 years of radio engineering excellence, Simoco combines innovation in two way radio design with extensive experience of delivering systems that connect people when it really matters.

As part of TTG, a leading provider of communications products and services, we use our expertise in trusted standards such as Digital Mobile Radio (DMR), P25 and Terrestrial Trunked Radio (TETRA) to provide integrated communications solutions. We support the operational needs of companies around the world and across five key growth markets: public safety and security, utilities, natural resources, transport, and government and public infrastructure. As we develop digital radio systems and IP communications at the leading edge of current technology, we maintain our focus on customer needs. Whether for day-to-day operations or for crisis situations, which demand a rapid and accurate response, our solutions are built around how people work best. When it really counts, the best systems are simply there, allowing people to connect, and at Simoco we never forget it's the connection that counts.

Simoco is headquartered in Derby in the UK, and has four regional businesses: Simoco EMEA, Simoco Americas, Simoco Asia Pacific and Simoco Australasia headquartered in Melbourne, Australia.

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