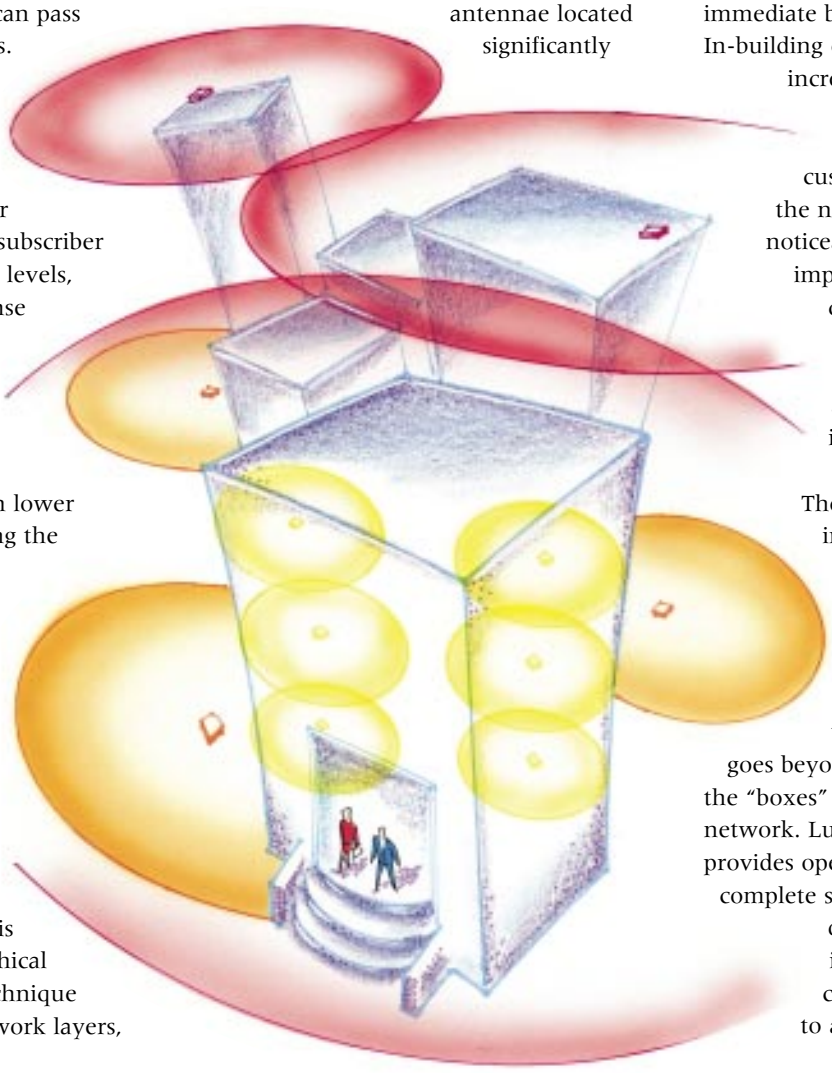
GSM – Enhancing Capacity and Coverage with Lucent's Hierarchical Networks

GSM is the technological success story of the late 20th Century. In just seven years the global GSM subscriber base has rocketed to over 100 million and there are confident predictions that this will increase to 300 million by early in the new Millennium. There are already almost 250 GSM operators worldwide and, as deregulation spreads ever wider, new GSM operators are receiving licences as fast as legislators can pass the necessary laws.

The incredible success of GSM, brings with it new challenges for operators. As the subscriber base grows, traffic levels, particularly in dense urban areas and city business districts, are beginning to stretch networks designed for much lower demand. Increasing the capacity of their networks is now the number one priority of GSM operators in mature markets.

One of Lucent's solutions for increasing network capacity is to adopt a hierarchical approach. This technique uses multiple network layers, consisting of macro, micro and pico cells. Macro cells use antennae located above the average roof top height to capture users moving quickly through the area, for example drivers on urban highways. Within each macro cell there will be hot spots where traffic density is high and the users are moving slowly. These areas are best covered by micro cells, with radii of 100 to 250m, which use antennae located significantly below the height of the surrounding buildings. If the user then moves indoors, the call can be switched to a pico cell. These very small cells, with radii typically less than 50m are more applicable to indoor areas where a high level of stationary and pedestrian users are found.



For operators who do decide on the hierarchical approach, the immediate benefits are obvious. In-building coverage levels will increase dramatically, increasing call revenue. For existing customers the quality of the network will show noticeable improvement. By improving coverage and quality, the customers will be satisfied and the operator will see a significant reduction in churn.

The perceived complexity in designing and installing a hierarchical network means it makes sense for operators to work with a company which goes beyond simply providing the "boxes" which make up the network. Lucent Technologies provides operators with a complete solution, from initial design, through to installation and commissioning and on to after-sales support.

Infrastructure Products

Lucent's Base Station Sub-system (BSS) supports GSM 900 and GSM 1800. The products include the Base Transceiver Station family (BTS-2000), which covers the Compact BTS (BTS-2000/2C) and the Base Station Controller Frame (BCF-2000) and Speech Transcoder Frame (STF-2000).





The BTS-2000/2C is a compact base station containing two 5W radio transceivers which makes it the highest powered base station with two radios currently on the market. This high output power enables the BTS-2000/2C to be deployed as either a microcell or a macrocell. For an indoor distributed antenna system, the high power levels of the BTS-2000/2C mean that less base stations are required to provide comprehensive coverage.

The Compact BTS-2000/2C (highlighted) is easily installed and remains unobtrusive

The BTS-2000/2C also offers synthesised frequency hopping on the second radio, which triples the capacity of the two-radio system. All of this, combined with its compact size, light weight and easy installation, makes it the ideal option for indoor or outdoor applications where real estate is at a premium.

Lucent's BTS-2000 family has flexible, modular base station solutions for both indoor and outdoor deployment. The BTS-2000 indoor offers up to 12 radio transceivers in a single ETSI frame, an important feature in terms of site acquisition.

The BCF-2000 is one of the highest capacity Base Station Controller (BSC) products on the market. Housed in a single ETSI frame it can support up to 1,000 Erlangs of traffic, which translates to 180 BTSs and up to 256 radio transceivers - approximately 20,000 subscribers! The STF-2000 provides highly reliable, cost-effective speech transcoding. Together, Lucent's STF-2000 and BCF-2000 make up the BSC which can be configured to provide significant transmission cost savings and to offer maximum flexibility in equipment placement.

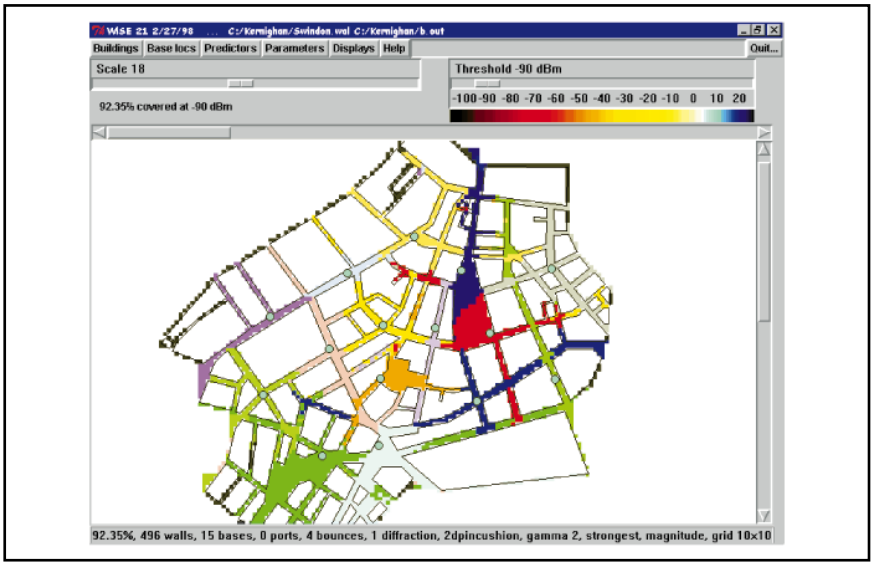
Hierarchical Approach

To make a hierarchical network structure effective, there must be algorithms in place to maximise the efficiency of the network by optimising the amount of traffic on each layer. Traffic is switched between layers based on the speed of the mobile passing through the network. For example, a mobile user in a car travelling along an urban highway will automatically have their call carried on the macrocellular layer. As they approach a junction and slow down, the call will be maintained on the macrocell layer to ensure that when they move off again there is no rapid decrease in coverage and the call isn't dropped.

Pedestrians walking across a footbridge over the same urban highway will have their calls carried on the microcellular layer. When they enter a shopping mall the call will be switched to the picocellular layer. The key to making this reactive hierarchical network effective is the seamless handover between layers.

By adopting this hierarchical approach the operator will see major capacity increases, since the spectrum is used more efficiently in the microcell and picocell layers.

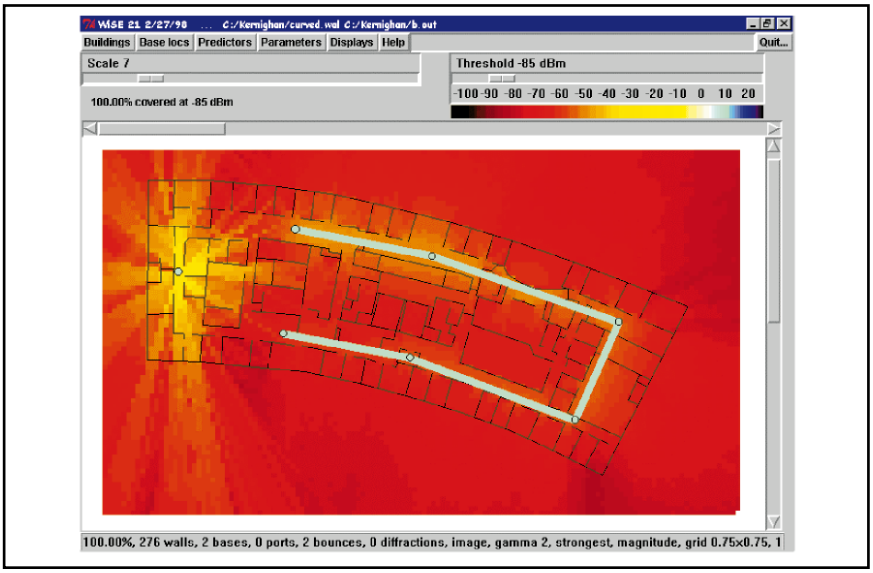
In the microcell and picocell layers of the hierarchical network there can be very large variations in signal strength, for example when going round a corner or entering a building. These situations can result in dropped calls. Lucent has developed unique algorithms that reduce the probability of a dropped call when the signal strength suddenly falls. In such cases Lucent's algorithms instruct the mobile terminal to instantly switch to full power, thus minimising the chances of the call dropping.



An example of an outdoor campus area microcell calculation using WiSE showing the coverage areas for a number of microcells

Tools

Designing a hierarchical network may at first glance seem to be a daunting task. Ensuring the optimum location for base stations and antennae is not a trivial task – which is why Lucent has developed its network planning tools, Wireless System Engineering (WiSE) and Handover Optimisation Tool (HOT). These tools are used by Lucent's engineers and system specialists to obtain the optimum hierarchical solution from an operator's network.



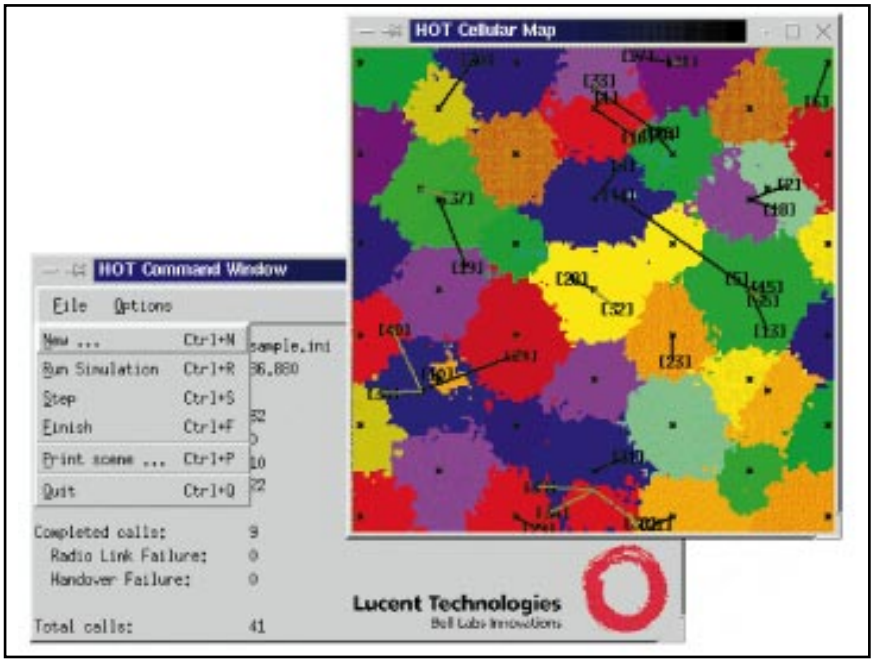
A WiSE prediction of coverage inside a building using a point source antenna and a leaky feeder

WiSE Ray Tracer is a predictive tool that uses architectural information to build a 3D software model of the area. It uses an extremely accurate technique to allow Lucent's network planners to obtain rapid and accurate estimates of RF signal strength and coverage needed within a GSM network. Ray tracing uses a large number of complex calculations to predict the network model, which in the past using conventional methods has taken days to produce. Now, thanks to the skills of mathematicians and engineers at Lucent Technologies Bell Labs, the WiSE Ray Tracer can perform the myriad of calculations required in minutes. A recent benchmarking test has shown that WiSE is accurate down to 6dB standard deviation between predicted and measured results, an accuracy far in excess of any other coverage modelling process.

WiSE takes the guesswork out of microcell and picocell design. In the past, deciding on the locations for microcells and picocells was done by trial and error. Experienced network planners could estimate the best locations for the base stations, but if they were not accurate enough, then the base station would have to be moved until the best solution was achieved.

For indoor coverage the planner can input information on room sizes, and construction materials used in the building. WiSE can predict the coverage from both distributed antenna systems and leaky feeder systems.

WiSE can also be used for outdoor locations – the planner simply enters information on the size, shape and materials used in surrounding structures, then the microcell configuration can be calculated. In addition it is possible to predict the effect of the coverage from inside to outside and vice versa.



A HOT simulation showing how mobiles are connected to a network

HOT provides a simulation environment that determines the handover parameters required to handle different speed mobile terminals passing through the network. HOT uses the data generated by the WiSE Ray Tracer and other RF planning tools. Utilising the actual network algorithms, Lucent engineers can use HOT to set up what-if situations, enabling them to determine the effects of changing parameters both on the local cell and on the overall network. Without HOT, operators would need to make parameter changes to a base station and then analyse the traffic data over a period of days or weeks to determine the effects of the modifications. Lucent's HOT not only provides instant feedback on the effects of parameter changes, it is also an excellent problem solving device which greatly reduces the amount of time an operator needs to optimise the network for maximum efficiency.

In a multi-layered hierarchical GSM network, HOT can be used to ensure that mobiles can be forced into the microcellular or macrocellular layer depending on whether they meet certain criteria like mobile speed. It can also be used to balance the traffic in the network to optimise use of the infrastructure.

Conclusion

Hierarchical networks is just one in an extensive range of solutions offered by Lucent to support customers in getting the best from their networks. Only Lucent Technologies offers this unique combination of tools, products and algorithms to reap the immediate benefits of Hierarchical Networks with the minimum infrastructure investment.

With Lucent Technologies support and Bell Labs innovations, operators can be sure of a flexible solution without risk to the network or subscriber base. To understand in more detail how Lucent Technologies can implement a Hierarchical Network then complete the attached form or call the number on our business card.



If you would like to know more about our GSM Hierarchical Solutions please complete your details below:

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