BENEFITS OF A SOFTWARE-DEFINED WIDEBAND BASE STATION SOLUTION

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ABSTRACT

Wireless carriers have been faced with the challenge of implementing new cellular standards from the inception of wireless communications. As more standards emerge, this challenge grows greater, placing an ever-increasing burden on carriers. Software-defined radios (SDRs) have tried to alleviate this challenge, but have not gained a foothold in the development of new generation cellular base stations. This paper evaluates current options made possible by today's crop of SDR solutions, as well as their benefits and drawbacks. A new approach to SDR platforms is introduced, with a discussion of features available using today's semiconductor technology. The paper concludes with an examination of cost benefits for manufacturers as well as wireless carriers who adopt SDR base stations.

1. CHALLENGES IN TODAY'S NETWORKS

The world's standards institutes are still trying to harmonize the wide variety of cellular access technologies, but so far with limited success. Wireless carriers are challenged with huge investments for introducing these new access technologies in their networks. As an example, AT&T Wireless in the US is upgrading their network from TDMA to GSM/GPRS and then to EDGE. WCDMA implementation will follow.

Alternatively, European wireless carriers are challenged more by the fact that 2G networks have been highly successful and penetration is reaching its maximum. 3G network deployment becomes a high risk, because it is not certain whether new services will be attractive enough to move existing and new subscribers to the 3G network. In any case, there will be excess capacity installed in either the new network or as customers migrate from 2G to 3G, in the legacy 2G GSM/GPRS installations.

In traditional deployments, network upgrades have required the installation of new hardware and software, which puts a tremendous burden on the carrier. Some of the key issues associated with network upgrades are

- Additional space requirements
- Excess capacity – stranded capital
- Training of personnel
- Huge upgrade costs

Especially in market conditions such as those present today, carriers are forced to delay upgrade programs because of the capital expense, and the additional uncertainty that consumers will subscribe to new services enabled by the new network standard.

2. A NEW APPROACH

Software defined radios (SDRs) have been discussed for years now. The first products in use in the market today have demonstrated the capability of such a system approach. However, there has been no substantial deployment of SDR-based equipment. This may be due to several factors:

- Cost may be too high
- Flexibility too low
- None of the large OEMs offers a product
- Chip technology is not there yet

2.1. What is the ideal base station solution?

Today's base stations typically support only one standard such as IS 136 or GSM. Multiple single-carrier radios are installed in one cabinet to achieve the required capacity. With an SDR-based solution, several approaches can be taken, some of which are already in use, and others which have not yet been feasible to develop.

2.1.1. Programmable narrowband radio

The programmable narrowband radio supports the traditional single carrier architecture. The software determines which access technology will be supported.

This approach does not take advantage of all the capabilities provided by an SDR, because the hardware is limited as to the different bandwidth and dynamic range requirements it can support.

2.1.2. Programmable wideband radio

With a programmable wideband radio, the carrier is able to use the entire allocated bandwidth for a specific standard, e.g., the 19MHz band for PCS in the US or the 18 MHz band for GSM 1800 in Europe.

Compared with the single carrier solution, this solution allows multiple narrowband carriers to be accommodated in a single hardware platform. The specifics of how the network is to be configured can be done in software.

Two different variants are possible. The base station can either be programmed for a single standard supporting multiple channels, or it can support multiple standards *and* multiple channels as long as they are part of the same frequency band.

2.1.3. Programmable multiple wideband radio

This approach combines capabilities of the variants outlined above. Each transmitter can accommodate at least two frequency bands, e.g., the 850MHz and 1900MHz band. There are three possible variations:

- All bands carry the same radio standard.
- Each band carries a different radio standard
- Each band carries multiple radio standards

2.1.4. Programmable super wideband radio

This would be the ultimate solution. The radio would cover all allocated frequency bands for cellular use from 400MHz to 2.1GHz. In addition, it would be able to support multiple standards at the same time.

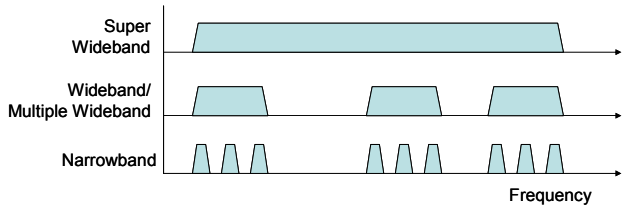


Figure 1: Radio Solutions

2.2. What can be achieved?

While the ideal solution is far beyond today's technical and economic reality, it is possible to achieve the second best solution – a truly wideband multi-standard radio.

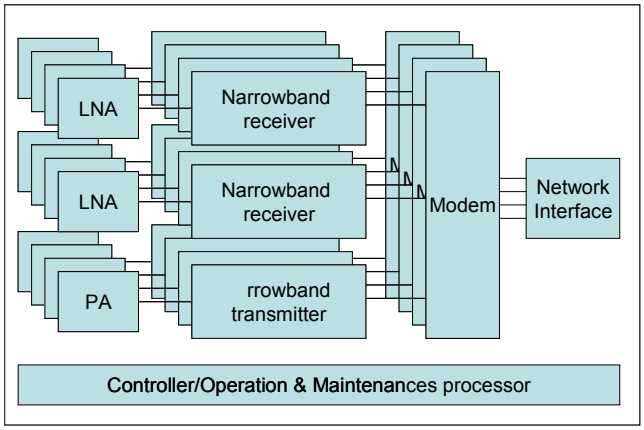
TelASIC is developing a chipset that will allow the implementation of a wideband architecture that supports multiple standards at the same time. A base station built with this chipset will be the first step in creating a standard, SDR-based independent platform.

This approach can be compared to the personal computer platform. For many years, computers have been able to support different operating systems and even more applications. Future versions of operating systems or application software can be installed on the "old" computer and work without modification.

Ideally, cellular base stations should follow the same concept. But is it economical to build such a base station? Are there more advantages than disadvantages for a wireless carrier?

3. THE ARCHITECTURE OF AN SDR BASE STATION

The following picture shows a simplified version of a traditional base station. The example represents a typical architecture comprising a number of single carriers, each containing the whole transmit and receive path, including receive diversity.

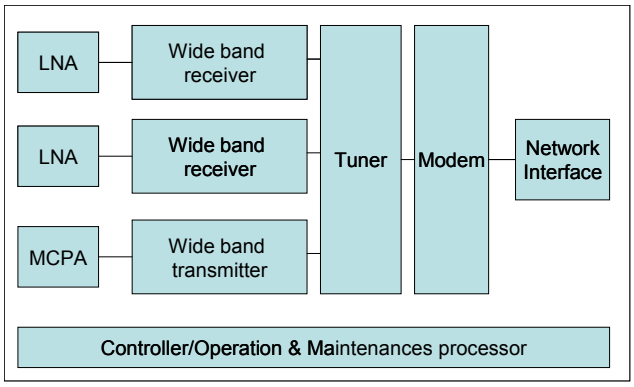


Most base stations are typically dedicated to only one standard and possibly multiple versions of these standards.

For example, the base station may support GSM, GPRS and EDGE, but not UMTS.

The typical functions of a base station are the LNA (low noise amplifier) and the receiver converting the RF (radio frequency) into a digital bit stream. The modem, typically a signal processor, will then recreate the original user information and forward it to the network.

By contrast, a base station built with SDR technology will consist ideally of only one transmitter and two receivers handling all the channels in the base station. The requirements for such a transmitter are much higher compared to a single carrier transmitter. Highly linear MCPA's (Multi-Carrier Power Amplifier) are needed to build wideband transmitters. The cost of these MCPA's has been a limiting factor in the past. On the receiver side, the conversion of RF to bits is a challenge. Today's analog to digital converters are not able to cope with the tough requirements of GSM 900. This is where the TelASIC chipset will offer a solution not possible with today's off-the-shelf chips.



The modem is the next bottleneck. It needs to have enough processing power to cope with future upgrades and the different radio standards. Modem implementations in traditional base stations are optimized primarily to support a single access technology for a single channel. Future modems need to be independent from any radio standard to give an SDR base station the full flexibility SDR can deliver to the market.

4. BENEFITS FOR THE WIRELESS CARRIER

The wireless carrier (operator) is the major beneficiary of an SDR base station. If such a base station existed in the network today, many upgrade headaches could be eased. Going from TDMA to GSM would be mainly a software upgrade. Just by upgrading one carrier from TDMA to GSM would increase the capacity from 3 to 8 traffic channels. Of course, this is only possible if MCPAs have been used in the base station. If they have not, the power amplifier needs to be replaced, an expense that is still lower than buying a new base station.

Since there are currently no SDR base stations deployed in a network, this example could only be applied in the future. Most operators are facing the problem of deploying the next generation – 3G – networks. Wouldn't it be nice if a base station could be deployed that also supports the legacy networks? It would mean a simple replacement of the old base station without losing capacity. No unused capacity is installed in the network, and channels can be switched from the old radio protocol to the new ones as subscribers move to 3G.

The following summarizes the substantial benefits an operator will realize once the new SDR base stations are made available to them.

- Site cost
  - No additional space requirements
  - No new antennas or combiners
  - Same network interface
- Installation
  - Only software download, minor cost
  - No additional warehouse space
- Operation
  - Training for people limited to new functionality
  - Little interruption of regular work
- Maintenance
  - No new spare parts
  - Same base station as before upgrade
- Other issues
  - Capacity growth as needed
  - No additional frequencies needed due to upgrade.

These benefits are dependent on the region. Some are only applicable to the US, while others are valid worldwide. But there are real savings. The number of physical visits from the service staff to the base station site can be significantly reduced. Just by assuming you could save an hour per site, with 5,000 sites a savings of up to $500k can be realized.

The total lifecycle cost of a base station can be greatly reduced even if the initial investment is higher.

5. BENEFITS FOR THE MANUFACTURER

What is in it for the manufacturer? Why would he invest in this technology since it will be a huge burden on his development budget? An SDR base station requires a new architecture that is quite different than what is presently deployed. Can a general platform base station compete with specialized base stations in terms of cost?

If an SDR base station of the first generation is compared to the nth version of a base station which has been shipped in hundreds of thousands, the answer may be no. However, if one platform replaces five or more product lines, the economies of scale which will be achieved by a SDR base station indicates an answer of yes.

There are a number of areas that are affected in the process chain of a company moving to an SDR base station. Once the initial decision has been made to invest in this program, the company will enjoy savings across almost all departments. This becomes increasingly important in a world of downsizing and pressure to reduce the burn rate.

The following list shows potential savings for a number of different departments.

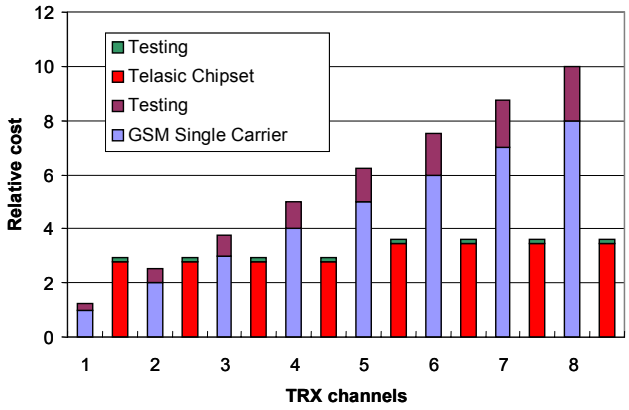
- Purchasing
  - Fewer parts
  - Significantly lower PCB cost
- Manufacturing

    - Smaller number of components placed - reduced time
    - Fewer circuit nodes - less complex ICT routine / fixtures
    - Reduced testing cost
        - No tuning
        - Reduced number of testing cycles
    - Less opportunity of errors – higher yield
    - One platform to manufacture – volume
    - Intolerance to forecasting fluctuation
- Logistics
    - Reduced inventory costs – less parts
    - Infinitely only one product line
    - Fewer spare unit variants required
- Development
    - Drop-in ready developed modules - "time to market"
    - Reduced complexity – less development effort and risk
    - One hardware platform for all access technologies
    - Reduced software effort – one platform
- Maintenance
    - Easy upgradeable – software only
    - Higher MTBF

Most of these savings can be turned into hard dollar savings. Figure 4 shows the savings for the RF (transmitter, receiver and tuner). The comparison is based on the components needed for a traditional RF solution for a GSM base station versus one built with the TelASIC chipset. Also included is the cost for testing the board. Additional savings such as the printed board or savings driven through the reduced space requirements have not been accounted for.

The breakeven point is between two and three carriers excluded here, the breakeven point would clearly move into the area between one and two carriers.

In times of shrinking margins, an SDR base station could be the right way for the infrastructure supplier to increase profit margins on radio base stations and improve product competitiveness.



CONLUSION

SDR technology has reached a point where the technology could provide substantial benefits to operators and their infrastructure suppliers at the same time. In a world of uncertainties about the future for mobile radio, SDR offers a safe migration solution, by eliminating the need to select one or the other access technology now. As markets grow, the operator could gradually introduce new standards, which creates a win-win situation for the operator and the supplier – as well as the end consumer.