Bridge Architecture: Revolutionizing Dual Mode 4G Cellular Modem Dongle Design

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In the continuous drive to keep consumers connected wherever they are, the cellular network has been an invaluable enabler. 3G and 4G connectivity, initially restricted to cellular phones, is now also widely available for portable computers. Initially a niche market for the business person on the move, cellular connectivity for laptops is currently experiencing an explosive growth due to college students and the new generation of latte sipping employees.

The device that enables cellular connectivity of laptop computers are known by a variety of names, including mobile broadband devices and laptop connect cards among others, depending on which carrier you talk to. For the purpose of this article we will group them all under the umbrella of Cellular Modem Dongles (CMD). As data revenues become increasingly larger in each carrier’s revenue pie, so has the growth in popularity of Cellular Modem Dongles. Currently, every major cellular carrier offers a complete line up of such devices for sale. These modem dongles range from the simplest 3G connectivity to modems with additional features, like SD expandability to even dual mode modems.

The simplest 3G modem dongle available in the market today is the single mode GSM or CDMA modem dongle. These modem dongles offer only the capability to connect to the cellular network for data needs. These devices are dedicated data transmitting and receiving devices which mainly consist of an RF chip, a baseband modem, and a power management IC.

With the market for modem dongles heating up, manufacturers have been trying to differentiate their products. The easiest differentiation is with the addition of an SD card slot for storing data, as this feature is usually included with the modem’s baseband processor and thus minimal design work is needed. However, beyond the simple addition of SD cards, today’s modem designer is looking to add new features to cellular modem dongle designs, particular having dual mode modem capabilities.

![Worldwide Data Card Forecast for 2005-2012](http://www.rfdesignline.com/)
When it comes to dual mode modem dongles, a few possibilities come to mind. They are:

1. GSM + CDMA modem
2. 3G + 4G Cellular modem
3. Cellular modem + WiFi

**GSM + CDMA**
In most cellular markets today, there are a mix of standards. The two main cellular standards of GSM and CDMA might work for carriers by tying subscribers to limited networks. However, this usually limits consumers, especially in developing countries where different carriers have better coverage in their own locality. Thus, just like the rise of dual mode cell phones in such countries, dual mode modem dongles will experience the same growth.

**3G + 4G Cellular**
Another popular CMD design today is a combination of 3G and 4G modems. These designs leverage the high-profile 4G cellular data service and the more widely available 3G data service. With most carriers today either choosing WiMax or LTE as their preferred 4G implementation, modem dongles are starting to incorporate these into their design while supporting more prevalent 3G connectivity.

**Cellular Modem + WiFi**
A third design option is the cellular modem and WiFi dongle. Although WiFi might come standard on many laptop PCs today, the new 802.11n standard is not yet integrated into PCs. Furthermore, due to carrier specification, many carrier-linked netbooks will not have WiFi capability. This will create a need for an additional device capable of providing WiFi connectivity when available and yet still keep the carrier’s data revenue stream intact.
Given the clear need and demand for such dual mode CMDs, one might question why is it that we have yet to see such products readily available. One of the main reasons for the delay to market is the complexity of designing such a device. For example, a dual mode CMD has to have the following specifications:

1. Both modes available
2. 500mA operating power consumption
3. Fast switching time between modes
4. USB performance

**Both modes available**

In order to have both modes available on a dual mode CMD, both processors need to be connected to either a hub or a bridge device. Some designers opt to use a switch instead in their implementation but this does not provide the dual-mode specification that is required by customers today. Therefore, for dual mode CMDs, bridges and hubs are the main interconnect chip considered for use between the two onboard processors and the USB interface to the mobile PC.

**500mA operating power consumption**

Due to the most prevalent connectivity option to a mobile PC or almost any PC today being USB, modem dongles are also mainly adopting this standard. As such, there is a limitation to the amount of current the modem can draw from a USB port. The USB2.0 standard allows for 500mA to be drawn by a device connected to a single USB port. Thus, when operational, a modem dongle only has the luxury of 500mA from the USB port. This is a major concern for many modem dongle designers as each of the main processor alone can potentially draw upwards of 400mA when operational. In addition, engineers must also take into account the interconnect between the two processors and the USB port when computing the total power consumption of the system in full operation. Under such a scenario where both modems are operational, the modems themselves will consume currents of beyond 800mA which is beyond the possible supply of USB2.0. However, many designers have understood that there is no scenario where both modems are working at full power simultaneously and thus the highest power consumption will be with a modem operating with addition to the interconnect chip. This is where using a bridge chip provides a significant advantage over the use of a hub. Assuming only 400mA power consumption from a modem, any addition of more than 100mA will cause the device to fail, thus ruling out the use of hubs in dual mode cellular modem dongles. Bridge chips that consume only around 80mA to 100mA will be able to keep the system within the specified current range.
Fast switching time between modes

Another important factor for dual mode modems is the capability to switch between modes as fast as possible. Depending on designer requirements, some designs require switching within microseconds and others milliseconds. A dual mode modem with a hub usually has a much slower switching time compared to a modem with a bridge chip. This is because hubs behave as a pass through and all instructions have to come from the PC that the modem is connected to. Similarly, all actions from one of the modems need to be passed along through the hub to the PC and relayed back to the other modem. In bridge architectures, the switching time is minimal due to the ability of the modems to communicate directly without needing to send data to the PC first. Even if data is to be sent to the PC, all communications can happen simultaneously and seamlessly. This minimizes the switching time between both modes.

USB performance

USB performance is another key factor in dual mode modem design. As USB is the predominant interconnect between the modem and PC, it is essential that the USB capability of the system operates at full capacity. After all, why have a modem that is capable of delivering more than 100Mbps of data if the USB capability of your system is limited to around 80Mbps?

This is another vital factor that put bridge chips in the forefront of these systems. Unlike a hub that just passes through the USB data coming from the modems, bridge chips can connect to other higher performance interfaces of the modems (for instance, the memory interface). This enables the modem to output the maximum data capable and not be gated by the integrated USB performance of the modem.

Apart from satisfying the main requirements of a dual mode cellular modem dongle, bridge architectures also bring additional benefits to modem designs. They are:

1. Independent datapaths
2. Flexible interfaces
3. Size

Independent datapaths

This feature is useful for dual mode cellular modem dongles due to the tight power consumption restrictions. Given the 500mA power limitation, it is vital that the modems are able to constantly toggle different power modes to keep the system in balance. The possibility of independent datapaths allow for communication and data transfer to happen simultaneously without needing to store data in a queue. This enables the possibility of constant toggling without upsetting the system’s fragile balance and interrupting data flow.

Flexible interfaces

Bridge chips also provide more flexible interfaces within a design, allowing developers to add an additional SD card or switch memory interfaces. This flexibility gives designers the freedom to readily swap features on their system while maintaining a fast time to market for their design.

Size

Many bridge chips are specifically designed for mobile devices. Their size is much smaller compared to hubs which are typically designed for computer peripherals. This is an added benefit to a mobile device like a USB modem dongle as size does matter. The smaller a CMD is, the easier it is to carry around.

The availability of cost-effective and power-efficient dual modem dongles promises to meet the requirements of both consumers and carriers. Through the use of bridge architectures, developers can enable dongle to satisfy all the needed specifications of a dual mode cellular modem dongle while enabling additional enhancements and functionality.
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