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Innovative Technologies for Backhauling HSPA Traffic

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Introduction

The broadband mobile revolution is happening right now, while mobile operators are busy planning the next generation of premium services. In Europe, mobile operators report soaring Mobile Internet usage, flooding the mobile network with data traffic that in some markets doubles or more every three months. Attractive pricing of data and voice packages has produced a surge in demand for mobile traffic, stressing to the limit the capacity and service delivery performance of the mobile network, and especially the mobile backhaul segment.

Only a few years ago the rollout of the first 3G services offering 384 Kbps data rates was considered a breakthrough technology compared with the traditional 2G services. Today's rapidly evolving HSPA networks offer 30 to 40 times higher data rates, and around the corner are new enhancements of HSPA+ and LTE that will dramatically increase data rate delivery to end users, targeting a peak rate of 100Mbps over the radio interface in a couple of years.

These enhancements in mobile broadband technology have led to significant changes in the mobile market – enabling the introduction of new cost-effective mobile data services. They transformed the mobile network from a voice–centric, low-capacity architecture into a new universe of multimedia services and data-oriented network architecture based on the IP protocol. The result is continuing pressure on the mobile backhaul network to increase capacity and service delivery, to flexibly support a transition of the network to IP, and to do it all cost-effectively.

Challenges of the Mobile Backhaul

The ever increasing capacity and lower cost of the new HSPA radio technology have not been matched by a similar scalability of the mobile backhaul network. Linking the cell sites with the mobile core network, the backhaul network has been based traditionally on E1 connectivity over a TDM transport infrastructure. Because scale up is limited and expensive, the backhaul network has become the bottleneck that holds back the expansion of mobile broadband usage.

Mobile backhaul challenges across the different markets and operators can be classified into four categories: (1) capacity delivery, (2) service delivery (3) network cost, and (4) evolution to a packet switched network (IP).

Capacity Delivery. The most urgent challenge of the mobile backhaul network is to increase capacity delivery. The objective is to match the progress of radio technology, which currently delivers 7.2M per carrier per sector and will grow to 40M with HSPA+ and to 100M with the introduction of LTE. Increasing capacity delivery involves upgrading the backhaul infrastructure (based on copper, microwave, or fiber) and upgrading the current TDM/ATM access switching infrastructure to packet switching.

Service Delivery. Raw capacity is necessary but not sufficient. The service delivery performance of the mobile backhaul network must also provide good user experience (QoE) to ensure the continued growth in usage of broadband mobile services. Rapid service introduction, high service availability, and QoS support are essential factors in assuring the end user experience and the success of mobile broadband. Service delivery performance factors such as high peak rate delivery, low end-to-end delay, and low packet loss are vital to provide an authentic user experience for mobile Internet applications; just as low delay and jitter are essential parameters in the delivery of voice and video applications.

Network Cost. Ultimately, it is cost constraints (both CAPEX and OPEX) that make the capacity and service delivery goals of the mobile network so challenging to achieve. Cost constraints are the result of the continuing erosion in mobile tariffs, especially with the new broadband mobile services where revenues per bit are considerably lower than in traditional mobile voice services. Therefore, to support the continuing evolution of new mobile services the cost of backhauling mobile traffic must be drastically reduced. Similarly to the capacity and service delivery challenges, backhauling cost is affected by all network layers, including the physical infrastructure, the transport layer, and the switching layer. Consequently, the efforts to open the mobile backhaul bottleneck and enable cost-effective capacity and service delivery must involve all network layers.

Evolution to a Packet Switched Network (IP). All communication services, both mobile and land line, will eventually migrate to IP bearer services running over packet-based networks. As part of this evolution, the mobile backhaul network will also migrate from the current TDM/ATM technology to a packet-based network. The question that still remains to be answered is exactly what type of packet-based network will the mobile backhaul be, and how will it get from here to there. Will the backhaul be a fully meshed, connectionless, layer 3 network with IP routing in every node? Or will it be a layer 2 PSN network, running mobile traffic in permanent or semi-permanent pipes? Will MPLS run initially over the TDM transport, with ML-PPP/POS, to protect the investment in the existing infrastructure, or entirely over a new packet-based transport network? What synchronization method will be selected for the new packet-based transport? And finally, how will OAM limitations be addressed and when will packet OAM mature?

Clearly, there are many different ways to meet the challenge of backhaul network evolution to IP. Decisions about how and when to migrate the network cost-effectively while protecting investments made so far and addressing the capacity and service delivery challenges at the same time may be the most important ones that mobile operators face in the coming years. Celtro's innovative solutions can greatly simplify some of these difficulties, by providing an integrated solution that addresses all components of the backhaul challenge in a coherent and comprehensive way.

Rising to the Backhaul Challenges

There are two complementary approaches to addressing the capacity, service delivery, and cost challenges of the mobile backhaul network: (1) upgrading the physical infrastructure, whether it is based on copper, fiber, or microwave; (2) expanding the deployment of switching solutions for aggregation, statistical multiplexing, and QoS support to improve network performance and enable higher capacity and better service delivery over the available infrastructure.

The challenges posed by HSPA traffic backhauling have been addressed traditionally by solutions such as statistical multiplexing with R99 or HSPA offload in hybrid network architecture. These solutions alone may not be adequate to cope with the projected future growth of the need for backhaul transport. To meet the challenges of the next generation of mobile broadband services, Celtro is the first to introduce innovative solutions for backhauling HSPA traffic (in addition to HSPA offload) that cost-effectively maximize backhaul efficiency and service delivery performance.

The innovative Celtro technologies combine to produce the following pioneering solutions:

Virtual bonding (PWE3 bonding) of HSPA traffic over multiple different links, like E1 and Ethernet, over xDSL, microwave, or fiber infrastructure. Virtual bonding enables cost-effective scalability of HSPA backhaul capacity and peak rate delivery to maximize end user experience.

Service-aware traffic classification and prioritization of HSPA user sessions for voice, video, and data to improve user experience and enable voice and video applications over HSPA.

Optimal convergence of 2G, 3G, and HSPA traffic over ATM or IP/MPLS backhaul networks. Optimal convergence maximizes network efficiency and provides full network flexibility in handling traffic demand variations and accomplishing the transition form 2G to 3G and HSPA.

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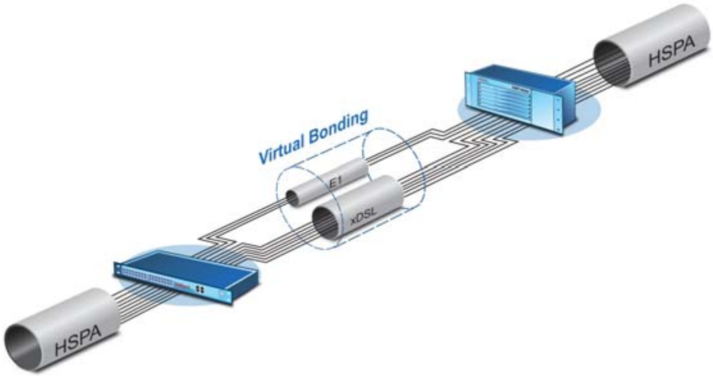
Virtual Bonding (PWE3 Bonding)

Celtro has developed a new mechanism that enables traffic bonding over different transport technologies (E1 and Ethernet) and infrastructure technologies (DSL, microwave, and fiber). Using the Virtual Bonding (VB) mechanism, backhaul capacity can be scaled cost-effectively to maximize HSPA peak rate delivery and improve HSPA service delivery and user experience.

The VB mechanism bonds together physically separated links that may belong to different networks into one virtual backhaul pipe with a peak rate delivery that equals the accumulated peak rates of the various links. VB can bond together links of ADSL2+, SHDSL, traditional E1s or E1 and Ethernet over microwave into one high-capacity backhaul pipe that carries HSPA traffic between the cell site and the RNC.

At the ingress to the VB mechanism, the single HSPA traffic flow is distributed over the bonded links based on link priority and available throughput. At the egress, the HSPA flow is reassembled maintaining the original order, delay is aligned to prevent jitter, and HSPA traffic flow is delivered to its destination. VB also provides load sharing between the different bonded links to enable traffic protection in case of link degradation or failure.

A simple application of VB is scaling of the offload architecture to support HSuPA. In a typical offload solution in Europe, HSDPA traffic is offloaded cost-effectively by means of ADSL2+. But with the introduction of HSuPA, the ADSL2+ is no longer sufficient because of limited uplink throughput. With VB, however, a single E1 can be bonded with ADSL2+ to increase uplink throughput from 1Mbps to 3Mbps, or 2 additional E1s can be bonded with ADSL2+ to increase the uplink throughout to 5Mbps. The figure below illustrates this solution.



The Benefits of Virtual Bonding

VB provides the following benefits:

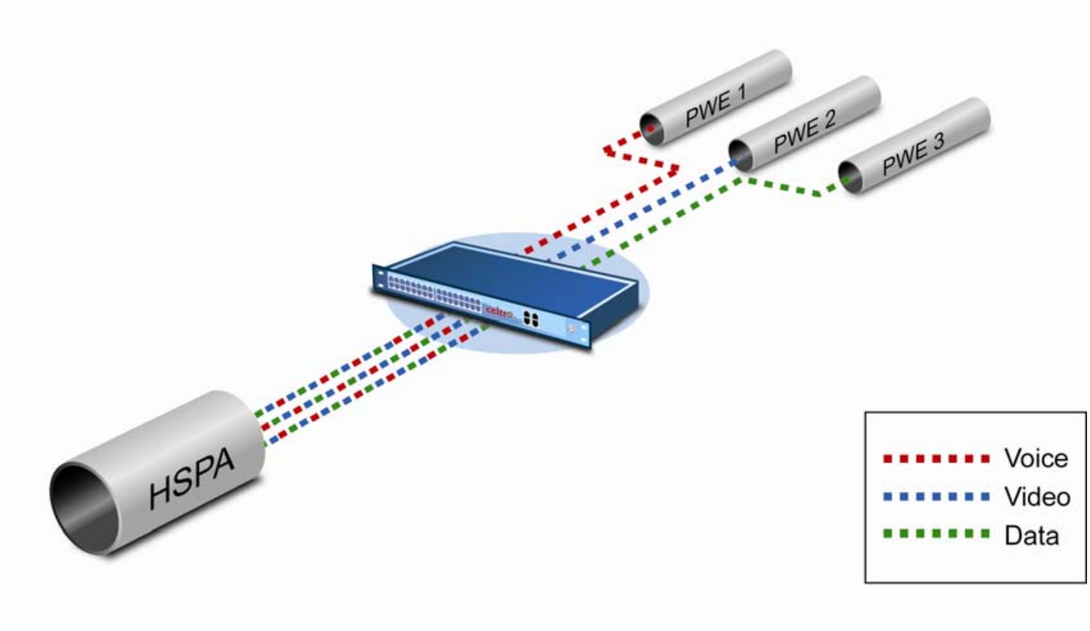
- Cost-effective backhaul scalability based on available low-cost links
- Increased HSPA peak rate delivery for better customer QoE
- HSuPA traffic over low-cost links (ADSL2+ and E1s)
- Load sharing for traffic protection against single-link degradation or failure

Application-Aware HSPA Traffic Classification

Celtro's application-aware traffic classification is based on the company's unique application-layer switching technology that enables voice and video services over HSPA. Celtro's innovative mobile backhaul switch can identify and classify each HSPA user session in the Iu-PS and determine the application and service being used (mobile TV, web-browsing, file download, VoIP, etc). The switch then maps the identified applications/sessions to a standard layer 2 QoS mechanism of ATM or MPLS to enable application-level traffic prioritization throughout the backhaul network. By providing application-aware traffic classification and marking at the edge of the network, the Celtro switch upgrades the entire backhaul network (which is based on standard switches) to an application-aware backhaul network with service delivery that prioritizes traffic based on user application of voice, video, or data.

Furthermore, application-aware traffic classification can be used to redirect traffic flows to different network sections based on the identified user application. For example, application-aware classification can be used in an offload scenario to redirect traffic when data cannot be separated based on layer 2 information alone.

The figure below illustrates the HSPA service-aware classification, prioritization, and forwarding mechanism. In the example, user sessions carrying different user applications are separated and carried over different PWE3 tunnels.



Benefits of application-aware backhaul

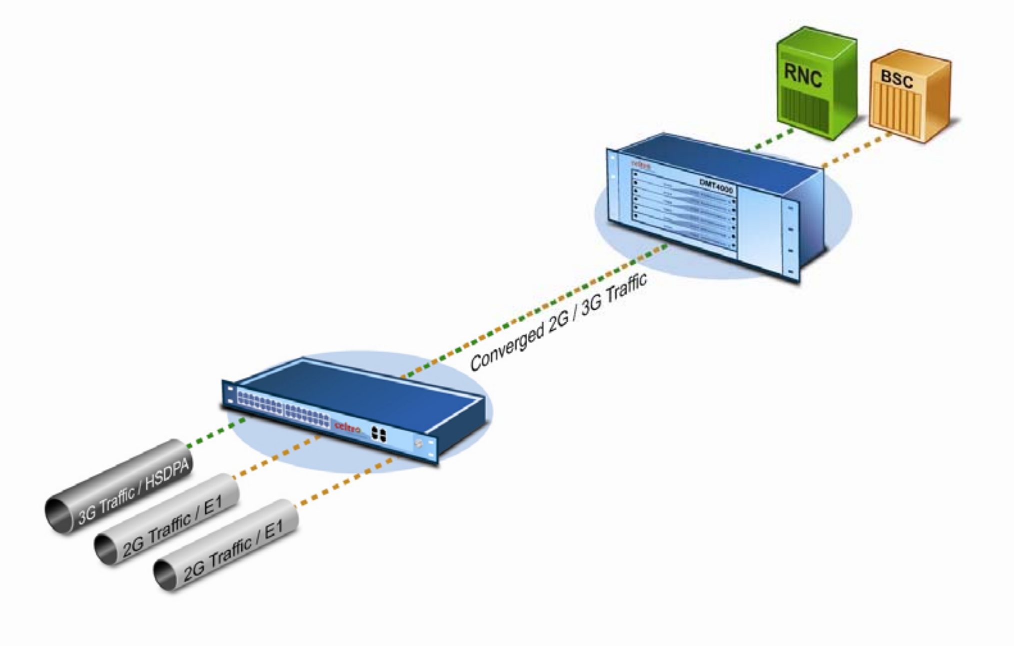
Application-aware technology and classification provides the following benefits:

- New revenue opportunities, including video and VoIP over HSPA
- Improved service delivery
- Traffic switching and redirection based on user application

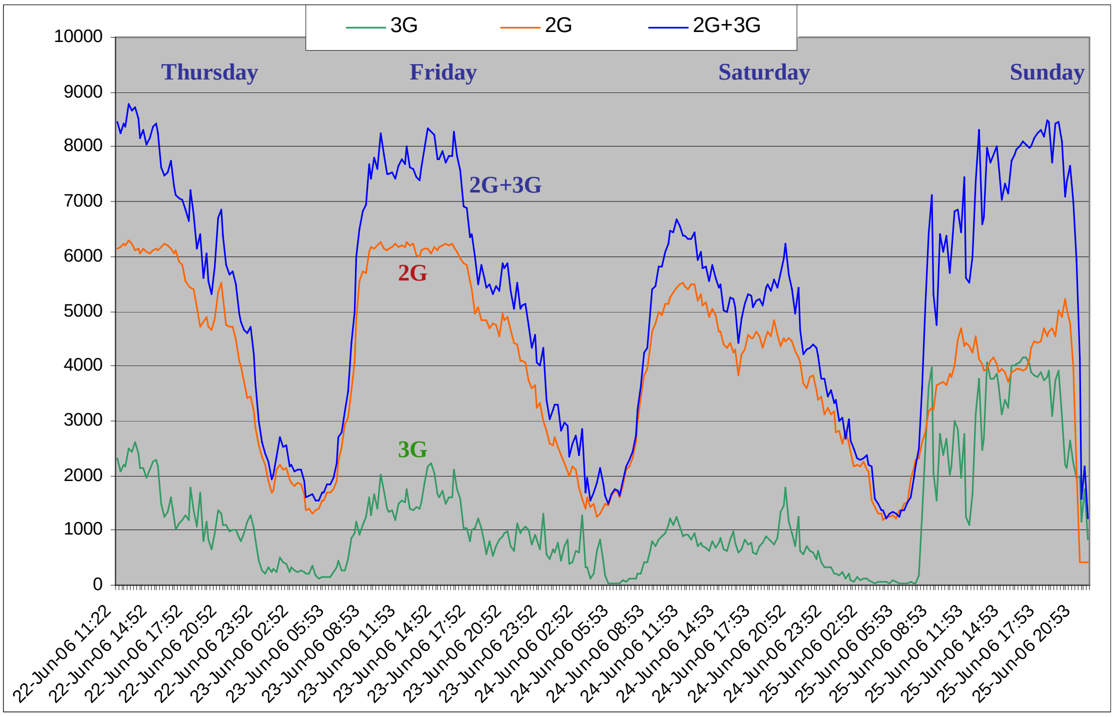
Optimal Convergence

Celtro's mobile backhaul switches provide optimal convergence of 2G, 3G, HSPA, and WiMAX traffic to maximize backhaul network efficiency and flexibility, improve service delivery, and reduce network expenses. Optimal convergence starts with optimization of all traffic types by eliminating idle and redundant parts and leaving only the actual information as a variable bit rate flow. The flows of actual information are then packetized into ATM or MPLS to match the backhaul aggregation technology. All service flows of 2G, 3G, HSPA, and WiMAX are statistically multiplexed to maximize statistical gain and dynamically share the backhaul resources based on QoS prioritization.

Statistical multiplexing and dynamic sharing among backhauled services improve network efficiency and maximize capacity and service delivery through the backhaul network. Dynamic sharing of backhaul resources also renders the backhaul network transparent to traffic demand variation between different mobile services and to customer and traffic transition from 2G to 3G and HSPA, and enables the rapid and cost-effective introduction of new mobile broadband services on time of low network usage .



The figure below demonstrates the benefits of optimal convergence in the initial rollout of 3G on existing 2G infrastructure. A cell site that was initially connected with 2 E1s for 2G traffic is upgraded to 3G, requiring an additional E1. With optimal convergence, the entire 2G and 3G traffic is carried over the 2 existing E1s. The figure shows traffic distribution over the E1s. The orange line describes 2G traffic after optimization and packetization, the green line describes 3G traffic, and the blue line represents the total traffic resulting from statistically multiplexing the 2G and 3G traffic. As can be seen in the figure, optimal convergence improves network efficiency so that 3 E1s (2 for 2G and 1 for 3G) are carried over 2 E1s, in other words, over the existing 2G infrastructure. The dynamic sharing of backhaul resources can be seen on Sunday, when 2G traffic decreases and increasing 3G traffic takes advantage of the available backhaul capacity.



Benefits of Optimal Convergence

The optimal convergence described above provides the following benefits:

- Higher network efficiency, greater capacity delivery through traffic optimization, and statistical gain for both 2G and 3G/HSPA traffic
- Rapid introduction of new 3G services and better service delivery based on dynamic sharing of backhaul resources by all services
- Reduction in network operational costs by better network efficiency and the use of a single unified backhaul network rather than multiple overlaid networks

In sum, to be able to offer the profitable services that customers crave, mobile operators must address several challenges on the backhaul side. For adequate mobile broadband **service delivery** they must be able to ensure sufficient **capacity delivery** to handle peak traffic, and **QoS support** to guarantee user experience. They must also acquire the **flexibility** to handle both legacy and current technologies, ATM alongside IP. Celtro's innovative technology, incorporated in its line of DynaMate mobile backhaul switches, rises to the challenge and helps operators stay one step ahead when planning the next broadband mobile revolution.