CASE STUDY
Intelligent Small Cell Trial
Intel® Architecture

Rethinking the Small Cell Business Model

Wireless data traffic continues to grow at an unprecedented rate. Cisco reported that in 2011 mobile data traffic experienced a 2.3 fold increase, reaching over 597 petabytes per month.¹ To meet this demand, the wireless industry has recognized a need to add small cells to the deployment options. A small cell can be defined as an access point that provides a higher capacity over a small coverage area.

The business economics for deploying small cells differs from that of traditional micro and macro cells. By definition, many more small cells are required to provide the same coverage as one macro base station. The site acquisition, installation and backhaul facility costs associated with deploying lots of small cells are considerably higher than the cost of deploying a macro cell. For small cell deployments to be financial viable, a new economic cost model is needed.

Over the past year, Intel and its partners have been conducting small cell trials that incorporate intelligence at the base station. This intelligence can be used to run network and application services on the base station. Trial results show that deploying intelligence at the access point can radically change the traffic profile, making the cost of deploying small cells increasingly viable.

Test results showed that deploying applications that improve the compression and transcoding of video stream, coupled with predictive and proactive data analytics substantially reduced peak traffic loads. Reducing peak traffic loads has two profound effects. First, it significantly improved the subscriber’s experience as loading web pages and downloading videos is notably faster. Second, it reduced the required data rate of the backhaul connections. For service providers that lease their backhaul connections, the savings are considerable.

This paper discusses several applications and techniques that reduced the peak traffic on a base station by over 45 percent. It then uses an industry recognized business model to quantify one of the key benefits, backhaul operational costs.

In 2011 mobile data traffic experienced a 2.3 fold increase, reaching over 597 petabytes per month.¹
Caching

In the next five years, Mobile data is expected to grow 19 fold. Analysis of this data is revealing trends in usage patterns, purchasing patterns, and demographics. Early trends suggest that there are many situations where multiple users access the same content. Examples include a release of a new version of the Apple* iOS, popular TV shows, viral videos, and geographically relevant content such as maps and restaurant guides.

Analyzing subscriber traffic and caching content locally at the access point has the potential to significantly reduce backhaul traffic. This is particularly notable on days when there are popular events such as a sports game or at locations where people congregate and watch the same video content on their individual devices. In these situations the mobile network will be inundated with requests for the same content. There are two primary forms of storing local content; predictive caching and proactive caching. Predictive caching is when a network provider predicts the type of data that the user will want and stores it locally. Proactive caching is when users request web pages that are subsequently stored locally.

Predictive caching downloads content at non-peak times when the backhaul links are not being fully utilized. Predictive cache reduces the amount of backhaul traffic when multiple users request the same content. It also evens out the traffic profile during the day, which reduces the load at peak times. Proactive caching directly reduces the backhaul traffic at all times of the day, including peak times. Backhaul connections typically guarantee a maximum data rate for a fixed price. These reduction in the peak load, directly reduce the backhaul operating costs.

Transrating Video Content

Typically, the backhaul network has a fixed data rate. The challenge for mobile service providers is to find an effective way to transmit multiple variable bit rate video streams over a constant bit rate channel. Transrating takes any video format and reduces it to a lower bit rate encoded traffic stream while minimizing the impact on video quality. Transrating can adapt to changing bandwidth conditions. As demand for bandwidth grows, transrating can reduce the video bit stream to a minimum to allow more video streams to be processes.

Over 50 percent of traffic over mobile networks is video, and this number is expected to grow to over 66 percent in the next five years. This growth in video traffic makes transrating increasingly important for reducing backhaul traffic and the associated operational costs.

Encoding and decoding of real time traffic streams is computationally intensive. It requires an intelligent platform at the access point and a server at the other end of the backhaul link to do the encoding and decoding.

Newer transrating techniques can vary the reduced bit rate based on the availability of network bandwidth. In other words, transrating can further reduce the bit rate when the network becomes congested at peak times. As mentioned above, reducing the peak load has the largest impact on reducing the backhaul costs.

Users are uploading and downloading video content in a range of different formats. This is particularly noticeable when the same bit-stream is distributed to devices that support different decoders. In addition to transrating the video traffic over the backhaul link, a service provider can leverage the local storage capabilities of the intelligent access point and store video content in several popular video formats. This enables service providers to deliver the same content to multiple users in the format best suited to their device. It also enables the operator to deliver a higher quality video experience to premium high paying users and a lower bandwidth video experience to non-premium users.
Trials realize the benefits of intelligent small cells

In 2011, to test the concept of an intelligent small cell in a live environment, Intel worked with Edge Datacomm* to deploy small cells on a train in the town of Kenilworth, England. Intelligent small cells were deployed on a four carriage train, and two 3G links from different service providers were aggregated together to provide the backhaul link. The intelligent small cell used proactive and predictive caching techniques to predict the data that should be stored locally on the train. Predictive data included the BBC* news, train time tables, film reviews, and maps. The intelligent small cells also identified and compressed JPEG videos.

Data was collected over a 25 day period. The trial results showed that an average of 200 users accessed the network in any one day. Each of these users transmitted and received on average 22 megabytes of data per day. Figure 1 shows that on a consistent basis, over 17 percent of the transmitted data was proactively cached and 16 percent was predictively cached.

Figure 1. Percentage of transmitted data that is cached plus image compression

Facebook was the most accessed site, followed by the BBC and Google. Many web pages, such as Facebook, have repetitive elements that can be stored in cache. Caching this content means that these pages will load very quickly on user devices. This is an important benefit to the user, as they will have the perception that the network is very responsive to their requests.

In this trial, the total backhaul traffic was reduced by over 45 percent, and the operator reported a 22 percent saving in operating expenditure (OPEX). Figure 2 shows a sample of user data transmissions taken over a 24 hour period. The blue line shows data transmitted on the downlink from the network to the user. The green line shows data transmitted on the uplink from the user to the network. The peak data rate was approximately 1.6 Mb/s on the downlink.

Figure 2. Data transmitted over a 32 hour period
**Integration of Wi-Fi in small cells**

The mobile industry has been integrating Wi-Fi and cellular networks for over ten years. Significant effort has been placed into defining standards that enable seamless coexistence and handover between these technologies. In the past year new trends have emerged which suggest that Wi-Fi should be integrated in small 3G and 4G cells.

Most people are not surprised that over 92 percent of smartphones now include Wi-Fi. What is surprising however, is that today over 70 percent of mobile data initiated by smartphones is on Wi-Fi networks.\(^3\)

Intel considers that this high acceptance of Wi-Fi is in part due to user’s familiarity with Wi-Fi networks in the home and enterprise environments, and partly due to the recent capping of data usage by most cellular service providers. The past year has also seen an unprecedented growth in Wi-Fi hotspots deployment by cellular service providers. Service providers like China Mobile* and China Telecom* that have both announced their intention to deploy one million hotspots. A large driver behind these announcements is the desire by mobile service providers to offload subscriber data from the cellular networks and on to the lower cost Wi-Fi networks.

The integration of Wi-Fi into a small cell enables data to be offloaded from the cellular network. This reduces the number of LTE access points required to meet the subscriber’s capacity needs. The integration of Wi-Fi does not reduce the backhaul traffic, but it does reduce the number of small cells being purchased along with the associated site implementation and operational costs. Intel’s analysis shows that integration of Wi-Fi in small cells offers significant advantages with a marginal increase in small cell equipment costs.

Another important trend is the growth in Wi-Fi hotspots deployment by cellular service providers in the past year. Service providers like China Mobile* and China Telecom* that have both announced their intention to deploy one million hotspots.

**Network OPEX savings in urban London exceed 22 percent**

To understand the impact of intelligent small cells in a large cellular network deployment, Intel worked with the independent market research firm Wireless 20/20.\(^4\) Wireless 20/20 have an industry recognized business case analysis tool called WiROI*. The WiROI tool provides in-depth analysis of the capital and operational expenses for the deployment of broadband wireless networks. Wireless 20/20 incorporated the operator’s data from the trial in Kenilworth into their existing WiROI model.

The Wireless 20/20 model predicted both the cumulative capital and

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\(^3\) By 2016, it is expected that over 10 percent of mobile data will be from tablets.\(^1\) This is an average of 1 Exabyte of data per month per tablet.
operational expenditures over 10 years with and without intelligence implemented at the access point. Figure 3 shows a deployment of regular small cells. Figure 4 shows the impact of integrating Wi-Fi, and adding caching and video compression functionality to the small cell. Both of these models are for Urban London.

The model shows that backhaul is the largest network operational cost. It showed that by adding intelligence to the access point that these backhaul expenses can be reduced from US$301 Million to US$ 191 Million; a saving of US$ 102 Million. While significantly improving the OPEX, intelligence at the access point only marginally increased the capital expenditure (CAPEX).

The increase in CAPEX is a combination of two factors: The increased cost of each access point, and the decrease in the number of required access points. The cost per access point increases due to the additional server and Wi-Fi equipment. The total number of required access points is reduced by 11 percent due to the integration of Wi-Fi. The integration of Wi-Fi also offloads data from the cellular network, which consequentially reduces the number of access points required to meet the subscriber’s capacity needs.

The Wireless 20/20 model reflects a reduction of over 7 percent in the total cost of ownership for small cell deployment in London.
the total cost of ownership over a ten year period. See table 1. These saving relate directly to the company earnings.

**Going forward**

The wireless 20/20 model was also applied for deployments in Tokyo and Mexico City. Tokyo shows similar savings to the London model, whereas in Mexico City the savings were disappointingly low. The costs of backhaul connections in Mexico City are higher than London and Tokyo, but the data usage is substantially lower. The reduced data usage caused the predicted savings for Mexico City to be substantially less. In general, the largest savings are in regions where both the backhaul costs and data usage are higher. The smallest savings are in regions where the backhaul costs and data usage are low.

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Table 1. Total cost of ownership comparison chart

Local caching and transcoding also promise to significantly improve the responsiveness of the subscriber’s experience. New lab and field trials are currently underway in different markets to further understand the benefits of data caching and video compression. Intel believes that local intelligence is essential for delivering an always-on and instant-response subscriber experience.

In addition, research is under way to investigate new ways to leverage the availability of local processing and storage capabilities at the base station. Some examples of new services are coupon distribution, local alerts, local social networking, and web site and content filtering. These services not only reduce operational and capital expenditures, but they have the possibility of generating new revenue streams for mobile network operators.

Local caching and transcoding promise to significantly improve the responsiveness of the subscriber’s experience. New lab and field trials are currently underway in different markets to further understand the benefits of data caching and video compression.
The Intel Solution

Wireless network architectures continue to evolve. The next phase of evolution is adding intelligence to access points in order to run applications at the network edge. These new architectures have a significant impact on service providers total cost of ownership and their return on investment.

Today, Intel has all the components that are necessary for service providers to transition to an intelligent access point and deliver applications at the network edge. **Figure 5** shows these components and how they interrelate. Components include a scalable Intel® architecture Host CPU to support deployments from small residential cells to large macro cells, standard Interfaces and connectors to enable easy expansion of the platform, and in base-station storage for data edge caching. Intel also provide extensive on-board memory for handling millions of computations, and an open platform for run Value Added services and functions at the base station.

Intel is working with several major service providers and other industry collaborators to implement cloud-based radio access networks. In the coming months Intel expect innovation beyond the predictive caching, proactive caching, and video transrating discussed in this paper. To stay connected with Intel advancements in this area see [www.intel.com/go/commsinfrastructure](http://www.intel.com/go/commsinfrastructure)
Note: Video traffic was throttled by the service provider due to the limited backhaul capacity. Transrating was restricted to compressing images only.

*Understanding today's smartphone user: Demystifying data usage trends on cellular & Wi-Fi networks*; Informa Telecoms & Media, 2012.