

A Tale of Two Bridges

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January 16, 2007

The challenge of making complex telecommunications engineering protocols understandable to those outside the industry is difficult at best. Attempting to explain how Rim Semiconductor's IPSL protocol is very different from and outperforms the existing standard VDSL 2, is a daunting challenge.

"A Tale of Two Bridges" attempts to do just that. By comparing and contrasting two very familiar objects, we hope to increase understanding of the unfamiliar.

The Golden Gate Bridge

The Golden Gate Bridge serves as the only northward escape out of San Francisco's congested downtown metropolis. Crossing its congested span is a necessary part of the commute to and from work for thousands who live north of the city limits. Commuters however, willingly accept this daily journey. The time consuming drive home is a small price to pay for access to a city that is a symbol of cosmopolitan lifestyle in America.

The Golden Gate Bridge was the brainchild of Joseph Strauss. Until 1937, the trek across San Francisco Bay was accomplished by ferry between the Hyde Street Pier in San Francisco and Sausalito, a bordering town in Marin County. The bridge was built to shorten the travel time between these two increasingly-popular destinations.

The bridge is 90 feet wide and has a total of 6 traffic lanes. Vehicles move simultaneously in north and south directions. With no barriers separating opposing traffic, motorists straying outside assigned lanes, assume a great risk.

Extra care must be taken by high-profile vehicles seeking to cross the bridge's 278 foot span. Frequent cross winds coming off the Pacific are potentially dangerous, and will at a minimum lengthen travel time. This fact makes large vehicles unwelcome travel companions.

Vehicles traversing the Golden Gate Bridge pay a toll when entering the city in the north-to-south direction only. Many commuters willingly pay the toll, considering it a small price to pay for access to the city. The Golden Gate Bridge accommodates over 100,000 vehicles daily. Most vehicles however, are manned by a solitary passenger, greatly diminishing the bridges capacity.

The congestion during rush hour can test the patience of even the most saintly. Traffic entering the city is bumper to bumper with vehicles both large and small vying for an advantageous position. Regardless of how skillfully one maneuvers through the snarl of southbound traffic, each commuter loses precious time when stopping to pay the toll.

The return commute in the evening is appreciably smoother because there is no required northbound fare. As result, the toll booth bottle neck is largely eliminated.

Given the congestion, is there a more efficient way to move traffic? *What if:*

- The tollbooth bottleneck could be minimized?
- More traffic lanes could be added?
- Each vehicle held more commuters?
- The vehicles were smaller, so as to allow for a greater number of vehicles to traverse the bridge simultaneously? After all, aren't vehicles just a method to transport commuters?
- Big rigs and other high profile vehicles were forbidden to cross the bridge because they require too much space and slow down traffic?
- There was a way to safely and effectively increase the speed limit on the bridge?
- There was a way to utilize all six traffic lanes to travel in a single direction? And then in accordance with demand, reverse the direction of traffic flow? Wouldn't this greatly increase bridge overall capacity?

The Oakland Bay Bridge

The Oakland Bay Bridge (or the Bay Bridge as the locals call it) opened in 1936, 6 months before its more famous neighbor, the Golden Gate. As result of ongoing modifications however, the older Bay Bridge actually supports much more traffic.

In order to minimize the toll booth bottleneck, the Bay Bridge has 20 toll booths spanning the entire width of I-80. Several of the booths are "Fas Trak" lanes, where the toll is paid electronically as vehicles speed past automated but unmanned booths. Fas Trak commuters rarely concern themselves with the plight of the uninitiated. Most vehicles slow each trip by paying their toll in the more traditional manner.

The most significant design difference between the two bridges is that the Bay Bridge is double-decked, or tiered. The entire width of the bridge supports traffic moving in a single direction. Westbound traffic coming into San Francisco is on the upper level. Eastbound traffic leaving San Francisco toward Oakland travels on the lower level. This design improvement alone more than doubles the bridge's capacity.

Because of Fas Trak, high occupancy vehicle lanes and continuous use of the entire bridge width (spectrum) for one-directional traffic flow, the Oakland Bay Bridge supports over 280,000 vehicles per day. This is almost 3 times the Golden Gate's present capacity.

Moving Forward

The two bridges illustrate the challenges and opportunities encountered in transporting high speed data between computers.

Traditional VDSL 2 technology is like the Golden Gate Bridge. Traffic flows in both directions simultaneously, splitting the spectral frequency (bridge width) between traffic moving in opposing directions. VDSL 2 uses large, high capacity, high-profile vehicles to transport data (commuters). These large vehicles are subject to crosswinds (transient noise) which slow travel time. Once data encounters sufficient noise it becomes unintelligible to the receiver and must be resent. This is analogous to strong winds blowing a high profile vehicle off the bridge... then having the vehicle start the trip all over again. This phenomenon greatly decreases the net payload that crosses the bridge.

In order for the VDSL 2 vehicle to traverse the bridge at high speed, conditions need be nearly perfect. No noise! Unfortunately, in the US, almost all the embedded wirelines are anything but perfect!

Because VDSL 2 vehicles travel in lanes moving in both directions, it is crucial that vehicles stay in their own lane. As result, VDSL 2 vehicles carry space (bandwidth) consuming bumper guards. Like the bumpers on a car, these bumper guards are designed to prevent collisions (crosstalk) with oncoming traffic. The downside is that these bumper guards take up valuable space (bandwidth) that could be used to transport more commuters (data).

Interoperability is the ability for an xDSL technology to co-exist on the same line with another xDSL technology. ADSL is the most widely distributed xDSL technology worldwide. ITU (International Telecommunications Union) standards require that xDSL technologies subsequent to or laid on top of ADSL not interfere with its function.

VDSL 2 has not performed well in this area. In fact, when layered on ADSL, VDSL 2 driving habits are so bad, ADSL performance suffers miserably. This is comparable to an impaired driver consistently swerving outside the assigned lane, causing accidents with other drivers in the vicinity.

In contrast, the IPSL protocol is more like the Bay Bridge. IPSL algorithms enable bi-directional traffic flow on a single level! Traffic flows one-way across the entire width of the bridge for a period of time, then in a millisecond, reverses direction and utilizes the entire width of the bridge to move traffic in the opposite direction. As result, every inch of the bridge is being used 100% of the time. And the length of time that traffic flows in a given direction can be increased or decreased to satisfy consumer demand.

IPSL vehicles are smaller and have a lower profile. As result they are more resistant to crosswinds (transient noise and crosstalk). In fact, with favorable wind conditions, the vehicles can accelerate their speed across the bridge to meet increasing demand! Because IPSL traffic uses the entire width of the bridge and doesn't encounter oncoming traffic, space (bandwidth) consuming bumpers on vehicles are unnecessary. This allows vehicle design to be smaller, enabling greater bridge capacity.

VDSL 2's method of loading traffic onto the bridge is called *Frequency Division Duplexing (FDD)*. When compared to traditional *Time Division Duplexing (TDD)*, relatively less toll booth processing is required.

IPSL's utilizes *Time Division Duplexing* to load traffic on the bridge.

To counter the increased required toll booth processing time, Rim Semi engineers have designed IPSL with "Fas Trak" lanes. IPSL enabled vehicles spend little time at the toll booths. AFE circuit settling time is minimized. There is a net payload capacity increase when compared to the large vehicle bumpers utilized in VDSL 2.

VDSL 2 traffic is optimized for downstream applications. Its directional flow is fixed at 80% downstream and 20% upstream. This results in inefficiency, in much the same way a bridge is inefficient during rush hour. Imagine the frustration of southbound Golden Gate commuters when stuck in morning bumper-to-bumper traffic while watching opposing northbound traffic whizzing along unhindered.

In contrast, the IPSL traffic directional flow rate is adjustable; from 50/50 for symmetric applications (enterprise spaces) to 98% downstream/2% upstream to support HD television streams (traditionally home consumers). This means there are never under-utilized lanes of traffic on the bridge, even in rush hour. Every lane is used to full capacity, 100% of the time.

In summary, when compared to VDSL 2, IPSL offers these advantages:

- Uses the entire width of the spectrum (bridge) for unidirectional traffic flow
- Moves more commuters packed in smaller vehicles (increased payload)
- Fewer traffic lanes needed to process vehicles at the toll booth (decreased latency)
- Lower profile vehicles that are less susceptible to crosswinds (noise)
- Much less interference with traffic on other levels (interoperable with ADSL)
- Increased vehicle intelligence (ability to accelerate data throughput as conditions become favorable)

As a commuter, would you prefer to traverse the Golden Gate Bridge the Oakland Bay Bridge? All other factors being equal, it would not be a difficult decision. The higher capacity of the Bay Bridge speeds the commute.