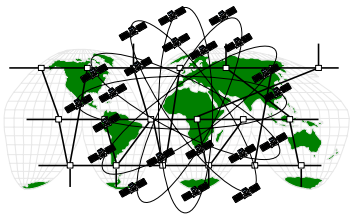
UNIVERSITY OF TRENTO - Italy
Department of Information and Communication Technology



Global Time from GALILEO for Overcoming Internet Challenges:

Switching Scalability and Streaming Media

Conventional wisdom has been that communications would soon converge onto a single universal Internet capable to effectively handling all data, voice and video services. Despite the significant effort spent in the last years, today this panacea is still far and there are still open technical Internet challenges. One of the primary objectives of the European funded project **IP-FLOW** (**IP FL**ows over **O**ptical and **W**ireless) is to show how global time or UTC (coordinated universal time, a.k.a. Greenwich Mean Time – GMT), which will be soon available from GALILEO, can be used effectively to overcome some of the most difficult Internet challenges.

Why Pipeline Forwarding is Significant:
The principle underlying this project is ***pipeline forwarding***, a method known to provide optimal performance independent of specific implementation. The novelty of **IP-FLOW** is the introduction of pipeline forwarding in the global Internet. The necessary condition for pipeline forwarding is having a common time reference, which in the context of the Internet should be the global time-of-day with proper accuracy. The accurate time is required in order to ensure ***"smooth flow"*** of data packets (i.e., with minimum delay and no loss due to congestion) over the global Internet. Specifically, what is required, for example, is that twelve o'clock at any two points around the globe will be within maximum deviation of no more than a few microseconds.

Why GALILEO is Significant:
In order to achieve such accuracy a sophisticated time distribution network is required, which is one of the main functions of the current GPS (global positioning system) satellite constellation and soon the GALILEO satellite constellation. Consequently, it will be possible to deploy UTC-enabled pipeline forwarding Internet switches on a global scale. Thus, one of the main objectives of the IP-FLOW project has been to design, construct and demonstrate a low cost UTC-enabled pipeline forwarding switch, using commercially available components. Specifically, the switch design guarantees deterministic quality of service and is scalable to 10 Tb/s (terabit per second) and beyond in a single chassis.

Why IP-FLOW is Significant:
Implementing a UTC-enabled pipeline forwarding switch, in a real testbed, that is scalable to multi-Tb/s switching capacity has been a rewarding experience to all of us who have been working on the project. The implementation success is a direct outcome of the simplicity of the pipeline forwarding switching method, which is demonstrated by a development time of only 9 months. It is important to note that our pipeline based architecture is at least twenty times more scalable than Cisco's top-of-the-line router, CRS-1, which has switching capacity of 640 gigabit/s per chassis, which moreover represents an improvement of a factor of only 2 after 5 years of development.

The significance of the IP-FLOW testbed is that the traffic on the Internet continues to grow exponentially (doubling, say, every eighteen months and not every five years!) and there is a real need to solve scalability and streaming media traffic engineering simultaneously — specifically, without using over-provisioning in order to ensure quality of service as done today. Pipeline forwarding also provides predictable performance for streaming media and large (content) file transfer applications. Another Internet open challenge is how to charge for services; users don't like to pay for services they don't receive or different quality from what they desire. The ability to provide predictable on-demand services has the potential to dramatically change the Internet business model.

IP-FLOW Testbed – See Diagram and Photo :
The ultra-scalable switch prototype was implemented at the electronic lab of the Department of Information and Communication Technology at the University of Trento, in collaboration with the Computer Networks Group of the Department of Computer Engineering at the Politecnico di Torino. The ultra-scalable switch prototype was demonstrated in the Communicating European Research Exhibition 2005 in Brussels (14-15, Nov. 2005).

IP-FLOW Information –
http://dit.unitn.it/~ip-flow/ :
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