Global Time for Overcoming Internet Challenges: Scalability with Guaranteed Performance

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7th Würzburg Workshop on IP:
Joint EuroFGI and ITG Workshop on
"Visions of Future Generation Networks"
(EuroView2007)
July 23rd - July 24th 2007

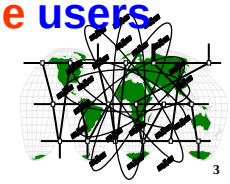
IP-FLOW European Project {EC Contract No. 002807}
http://dit.unitn.it/ip-flow/

Outline

- **Motivations**
- **Scalability with optimal pipeline forwarding**
- **Networking with performance guarantees**
- **Testbed validations**
- **Summary**

Motivations

- Two primary Internet transitions:
  - 1. From **business** to **home/mobile users**
    - The capacity per home will equal campus capacity
  - 2. From (telecom) **broadcast** to (all-IP) **on-demand:**
    - Triple-any: **anyone/anything(any-service)/anytime**
    - Global scale: **from anywhere to anywhere**
  - **Given continuous exponential traffic growth 50-100 folds (faster than "Moore's Law"), it's envisioned >95% of traffic will be to home/mobile users**



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Motivations

- Who will pay?
  - For 50-100 times larger Internet infrastructure and
  - When >95% of IP traffic is to home users
- **Given that service providers will not lose money again …**
  - This requires:
    - **Lower** complexity/cost of IP infrastructure
      - – **Using global time from GPS/Galileo/other sources**
    - **Increase** revenue from deterministic services
      - – **Using global time from GPS/Galileo/other sources**

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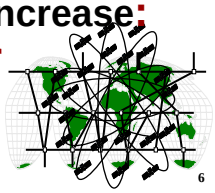
Global Time for Network Scalability
[Our Version of Globalization…]

- Global time is UTC (coordinated universal time) for time-driven switching – TDS / FλS
  - Sub-lambda switching or
  - Synchronous burst/packet switching
- **Network scalability index definition:** the ratio between the factor of network growth (scalability factor) and the factor of cost increase; **larger the scalability index the better**



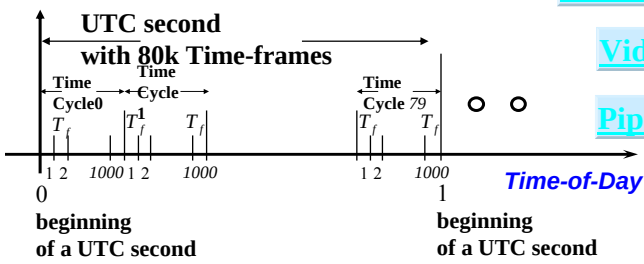
Pipeline Forwarding

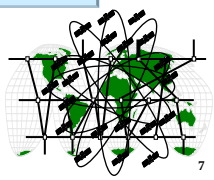
- **Pipelines are deployed to increase efficiency:**
  - **Optimal method** - independent of a specific realization
  - **Factory (automotive) / computers (CPU)**
- **Internet Pipeline thanks: GPS/Galileo/other sources**
  - **Time frames as virtual containers for IP packets**
    - **Thus, no header processing**
  - **T_f accuracy of 1µs is sufficient**

TDS Animation

Video with TDS

Pipeline





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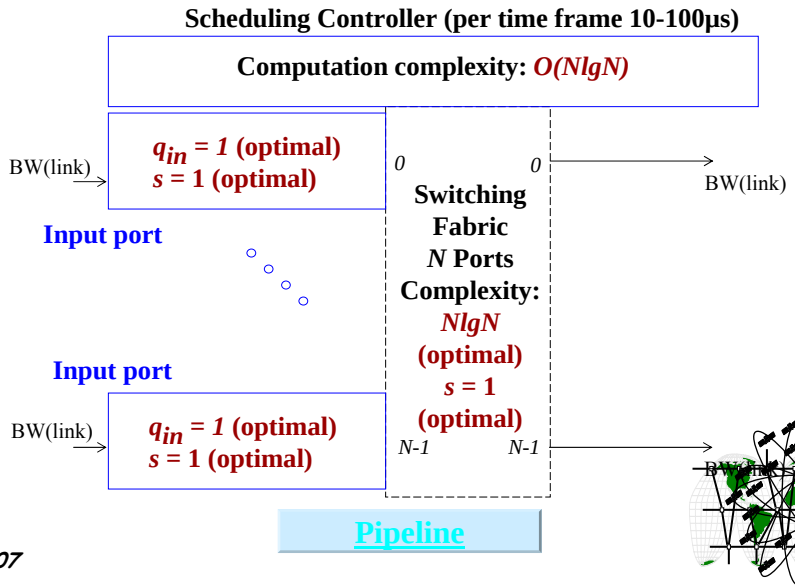
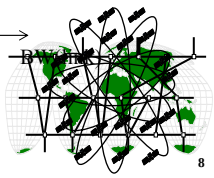
Scalability with Optimal Complexity



Pipeline



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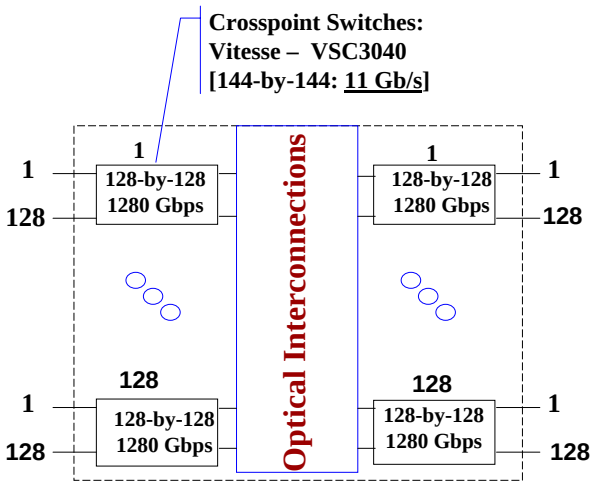
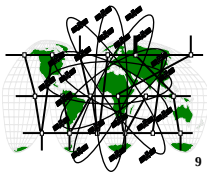
Example: 160 Terabit/s Fabric





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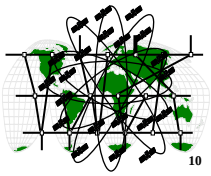
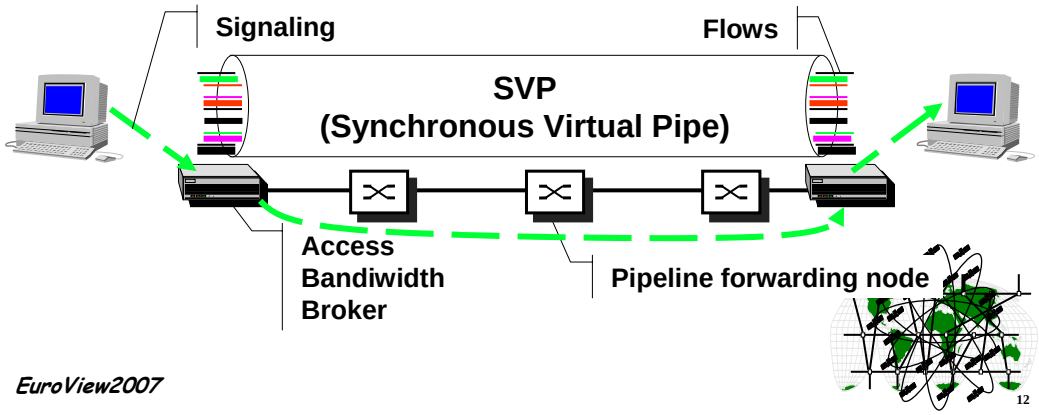


Networking with Global Time

- No header processing / no segmentation / no reassembly
  - 1. A small 1MBytes file = 1000 packets
  - 2. A 1GByte file = 1,000,000 packets!
- Delay per hop: constant
- Jitter per hop: zero
- Loss: none due to congestion
- "Bonus": QoS for streaming media
  - [Sort of a "negative option"]
- No "stopping" of the serial bit stream
  - Minimal buffering

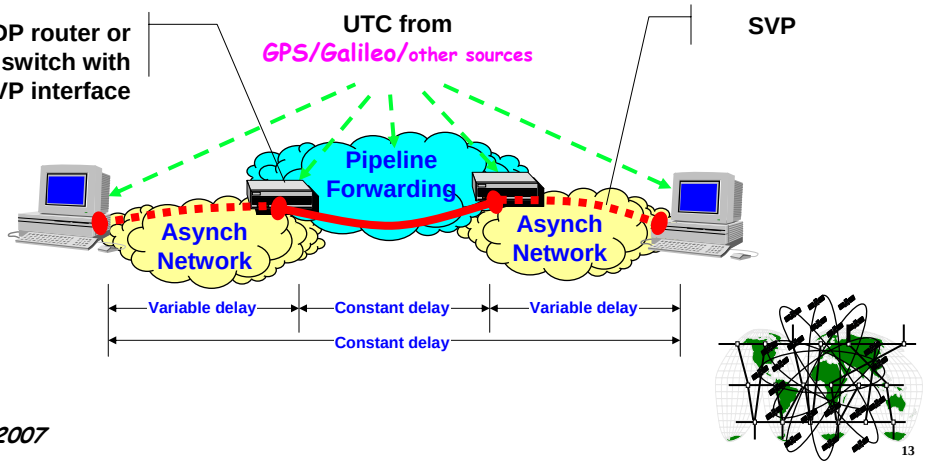
SVP for Plurality of Flows

Like VP (virtual pipe) in ATM
or
Like FEC (forwarding equivalent class) in MPLS
Setup with GMPLS (TE) (+ time semantic)



SVP Across Synchronous and Asynchronous Domains

Setup with GMPLS (TE) (+ time semantic)



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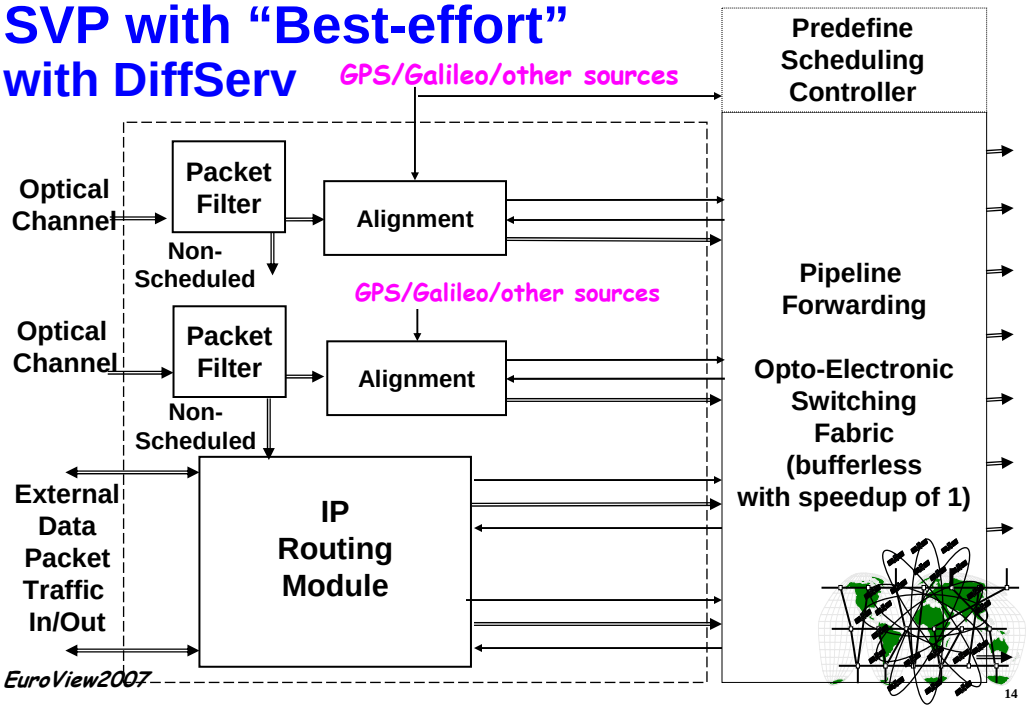
SVP with "Best-effort" with DiffServ



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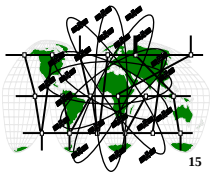
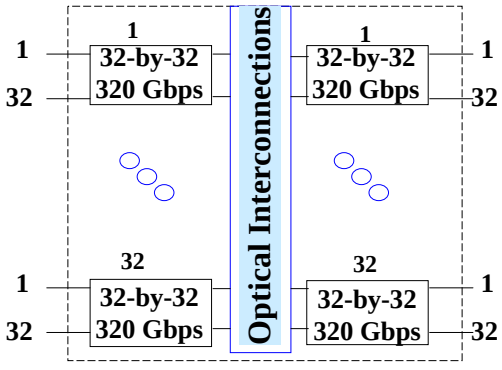
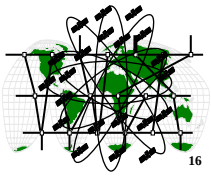


Current testbed: 10 Terabit/s

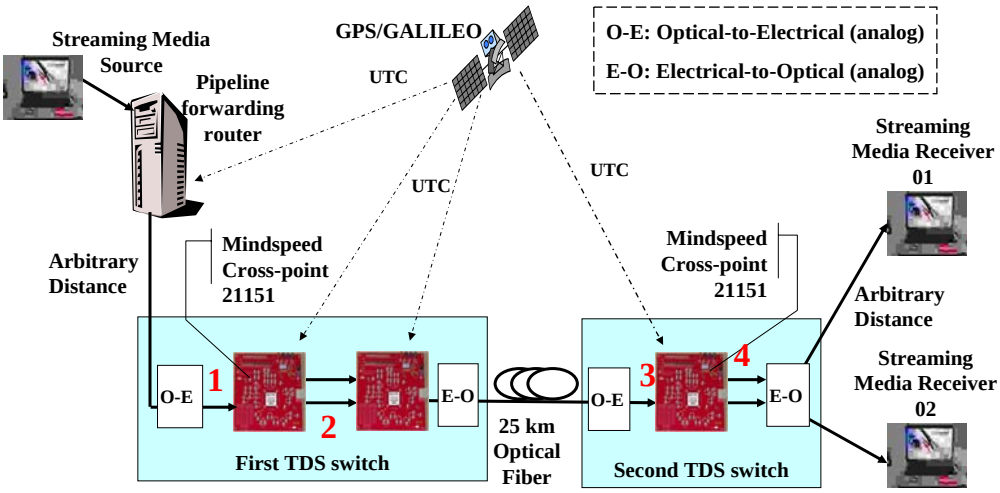
- All off-the-shelf components
- Using existing (5 years old) Mindspeed M21151 cross-point switches





Current Testbed Setup

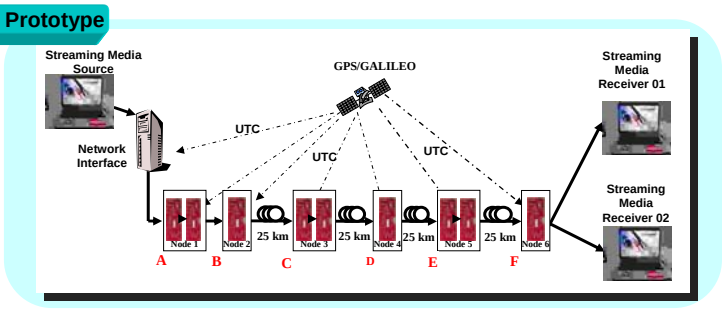
http://dit.unitn.it/ip-flow/



TDS Animation

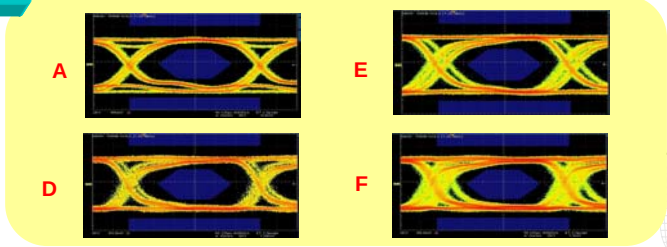
Current Testbed with 100 km

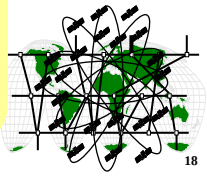
Extended Prototype



100 km fiber + 6 switching nodes

Measurements





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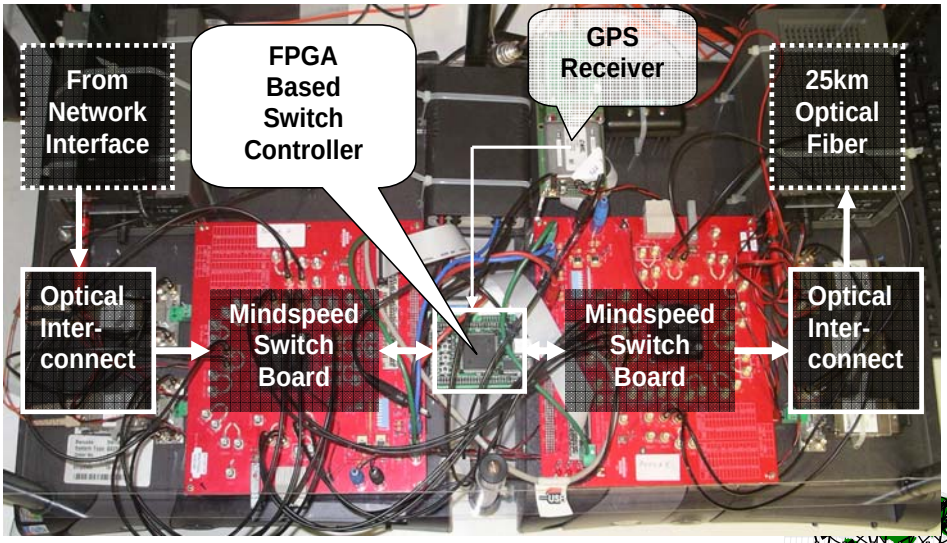
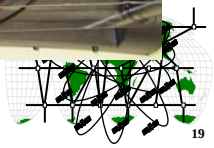
Switch Implementation

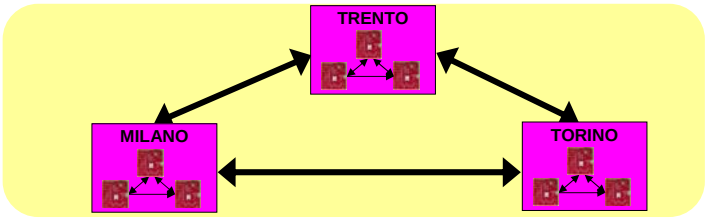


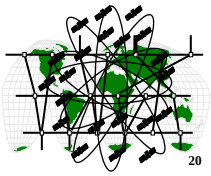
Carried out by Ph.D. students in 9 months



Current Wide Area Testbed

- U. of Trento
- Politecnico di Torino
- Politecnico di Milano
- Construction before August 2006
- Testing will start in September 2006

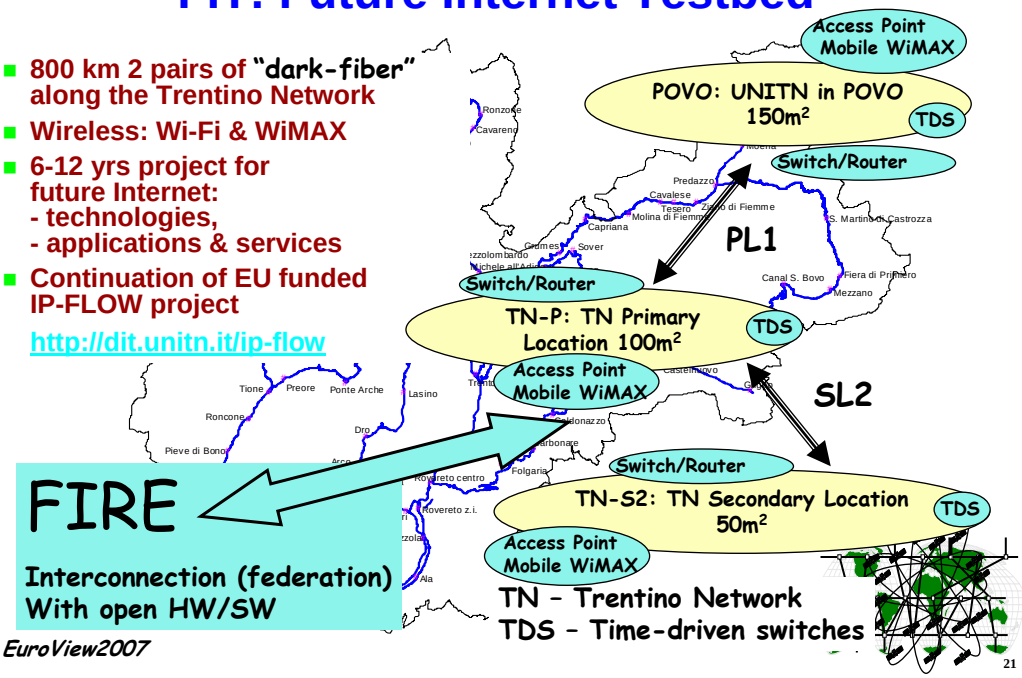




FIT: Future Internet Testbed

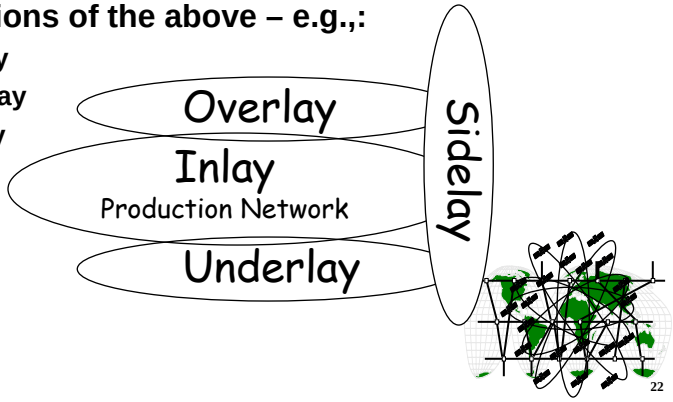
- 800 km 2 pairs of "dark-fiber" along the Trentino Network
- Wireless: Wi-Fi & WiMAX
- 6-12 yrs project for future Internet:
  - technologies,
  - applications & services
- Continuation of EU funded IP-FLOW project

  http://dit.unitn.it/ip-flow

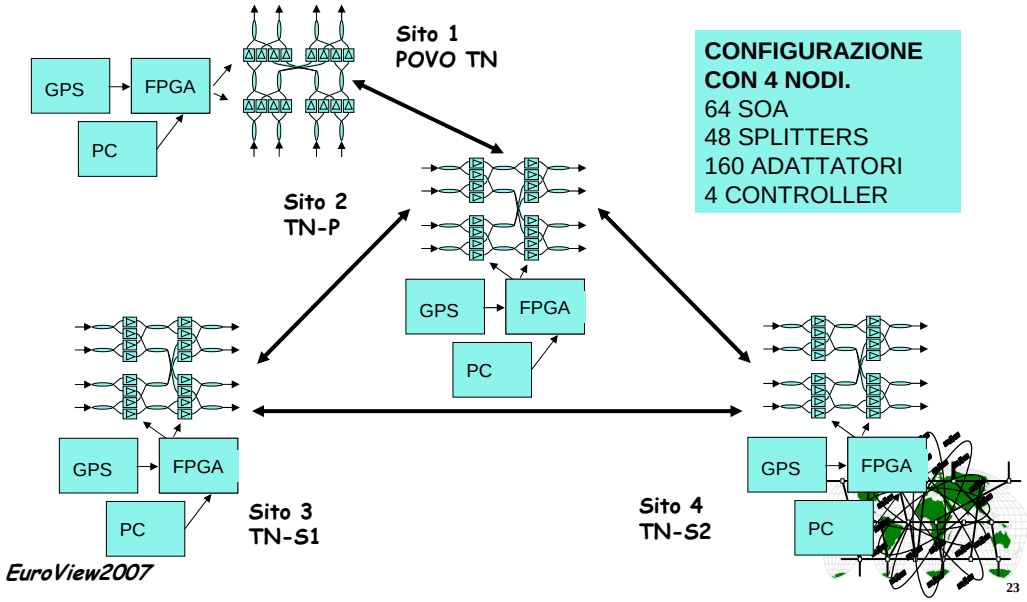


Overall FIT Structure

- Based on projects:
  - Overlay – services and applications
  - Underlay – networking – data plane
  - Inlay – networking – control plane = production network
  - Sidelay – access: wireless / PON / xDSL / …
  - Various combinations of the above – e.g.,:
    - overlay + inlay
    - inlay + underlay
    - inlay + sidelay
    - …



FIT: Experimental All-Optical "Underlay":
Controlled by the "Inlay" Production Testbed



Summary

- **Solving a major scalability problem, namely, much larger network for much lower cost**
  - **Switching (metro/core)** bottleneck
  - **Access (wireless) link** bottleneck
  - Efficient provisioning **from T1 to full channel capacity**
- **Base on existing protocols: GMPLS, DiffServ**
- **Viable for all-optical networking**
- **QoS as a Bonus! (i.e., no additional cost):**
  - **Guarantee performance (zero loss, min delay):**
    - **Consequently, increase revenue**
- **Extensive on-going testbed activities**
  - **With open HW/SW policy**

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