Conductor: Enabling Distributed Adaptation

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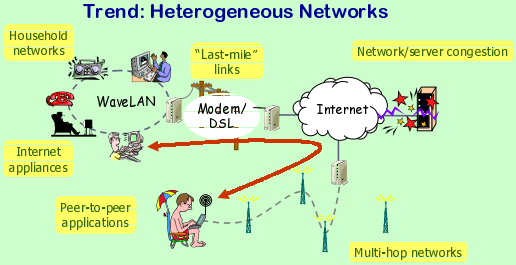
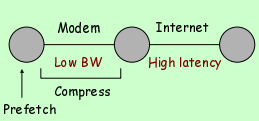
Trend: Heterogeneous Networks

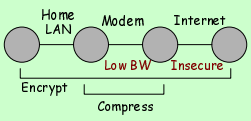


Heterogeneous networks benefit from Distributed Adaptation

- Adapt at various points within the network.
- Use multiple adaptations to solve multiple problems.
- Coordinate adaptations to ensure the desired effect!



Prefetching from the client exacerbates the bandwidth constraint. Prefetching should be performed from the other side of the modem link.

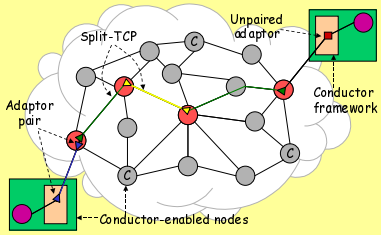


This typical case of uncoordinated adaptation leads to ineffective compression. This situation is easily avoided.

Conductor and Distributed Adaptation

Conductor helps applications provide gracefully degraded service in the face of heterogeneous networks with varying bandwidth, latency, jitter, security, reliability, and monetary cost.

Conductor provides an adaptation framework that can be incrementally deployed at a subset of network nodes. Client-server communications are intercepted on the client node and routed through Conductor-enabled nodes, allowing adaptation to occur at various points within the network.



Conductor allows an extensible set of adaptor modules to be automatically selected and dynamically deployed at Conductor-enabled nodes. Adaptors operate on application-level protocols and are frequently paired, converting to and from a more transmittable protocol.

Conductor provides application-transparent adaptation; legacy and closed-source applications are fully supported. However, adaptation is not always user-transmittable, so it must be user-controllable.

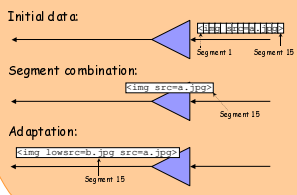
Reliability and Adaptation

Adaptation voids the assumption that data is immutable during transmission and introduces new points of failure.

Semantic segmentation integrates adaptation and reliability, providing exactly-once delivery of semantic content.

Semantic segmentation allows adaptors to express a correspondence between pre- and post-adapted data. Adaptors can also express appropriate points at which adaptation changes can occur.

Segmentation is dynamic, automatic, and based on adaptation and data types. Segmentation for a sample HTML adaptation is shown below:

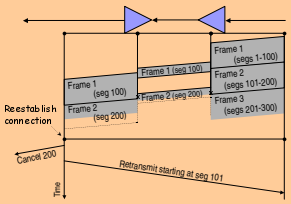


Since TCP is used between Conductor nodes, recovery is required only upon adaptor, node, or link failure.

After connectivity is reestablished, retransmission begins with the segment following the last complete segment received. Retransmitted data can be readapted according to current network conditions.

Conductor also includes a mechanism to reestablish appropriate adaptor composition after a failure.

Recovery after failure of a video compression adaptation is shown below:



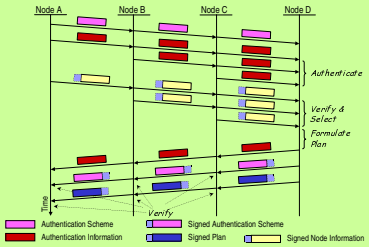
Securing Distributed Adaptation

Conductor includes a mechanism for automatic selection of adaptors based on prevailing end-to-end network conditions. This mechanism must be secured to ensure user control over selected adaptations.

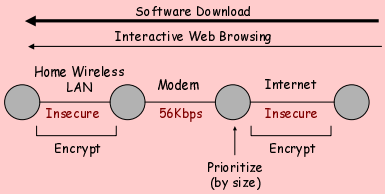
Conductor must provide a variety of levels of security for different users and different streams. Since Conductor crosses administrative domains, a variety of authentication mechanisms must be supported.

The secure planning protocol depicted below ensures:

- The selected security/authentication scheme is used by the planner.
- Trusted nodes can be identified.
- Untrusted nodes cannot influence planning.
- An authentic plan can be deployed.



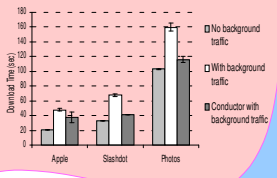
Example 1: Prioritization of Secure Web Traffic



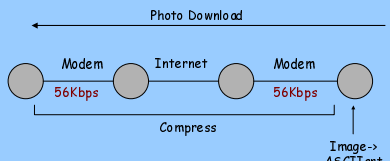
By giving priority to the interactive traffic, Conductor allows nearly the optimal throughput, despite the software download, while also encrypting the data.

Notice that end-to-end encryption would disallow prioritization, which requires access to the stream.

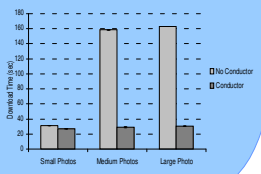
Results were obtained using three real-world web pages: the Apple home page, a Slashdot article, and a photo gallery.



Example 2: User-to-User Photo Sharing



By drastically reducing the image quality, Conductor allowed a photo-gallery to be downloaded in significantly less time.

While this adaptation would not be appropriate in all cases, Conductor gives the user control over selected adaptation.

Results were obtained from pages containing three different image sizes.