The Bandwidth Exchange

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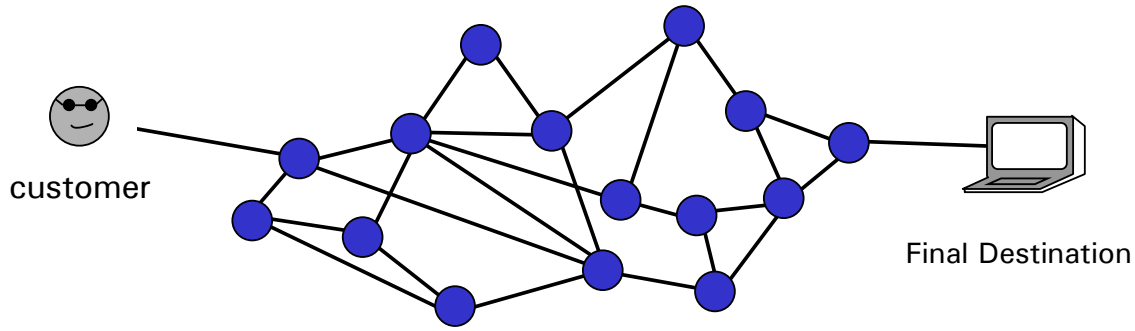
Concepts

- Why reserve bandwidth?
  - Grid computing.
  - Video, music on demand.
  - Multimedia applications.
  - Bandwidth is perishable.
- If its such a good idea, why aren't we using it already?
  - No commercialization model for the Internet.
  - No architecture for accounting and charging.
  - So far, applications did not require lots of bandwidth (e.g. VoIP)

Motivation

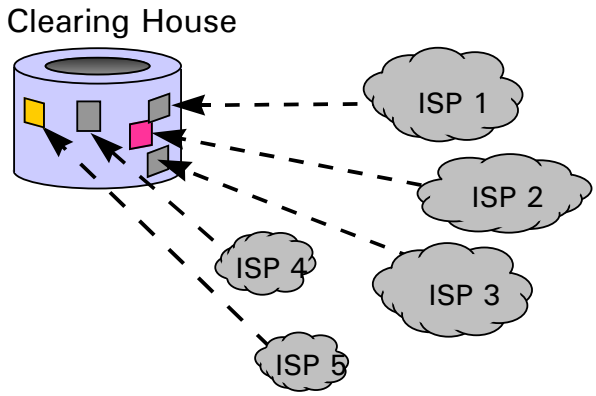


- Assuming that the various links are owned by different organizations, how can the customer construct a path from source to destination?
- Airline analogy

Bandwidth Exchange

- The bandwidth exchange is an on-line site where
  - network providers place quotes for their available bandwidth
  - customers browse for offers for bandwidth
- Futures Market
  - advance bookings
- Spot Market
  - used to allocate bandwidth that has not been previously reserved.
- Requirements
  - transparency (to ensure fairness).
  - assurances (to both buyer and seller).

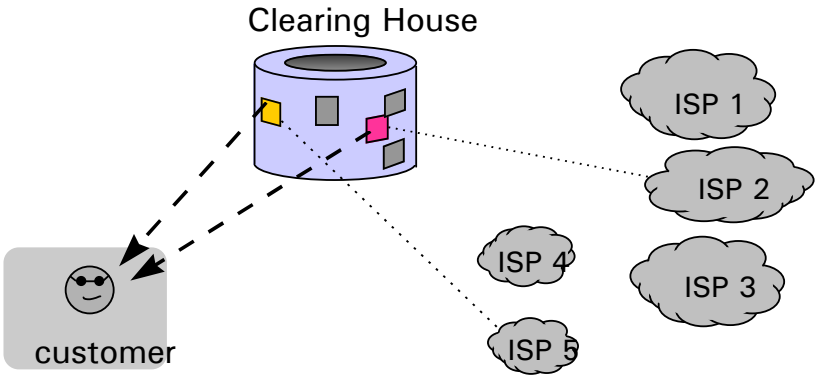
Band-X Architecture (1)



Example of Spot Market Operation

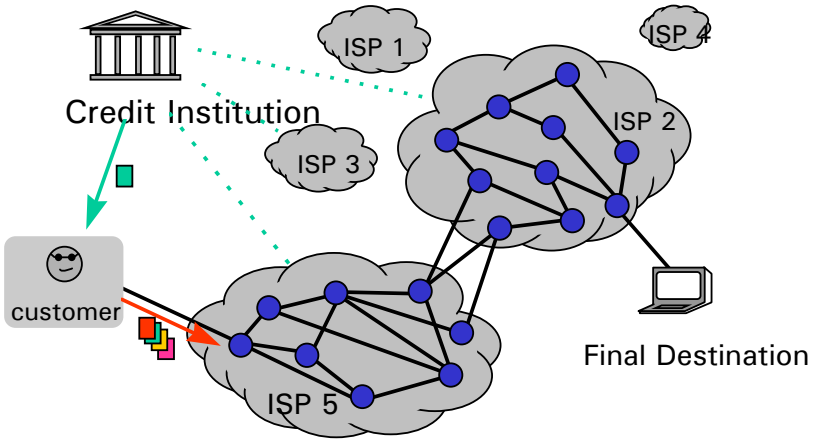
The BAND-X Clearing House acts as a repository of all the offers for bandwidth issued by the various ISPs.

Band-X Architecture (2)



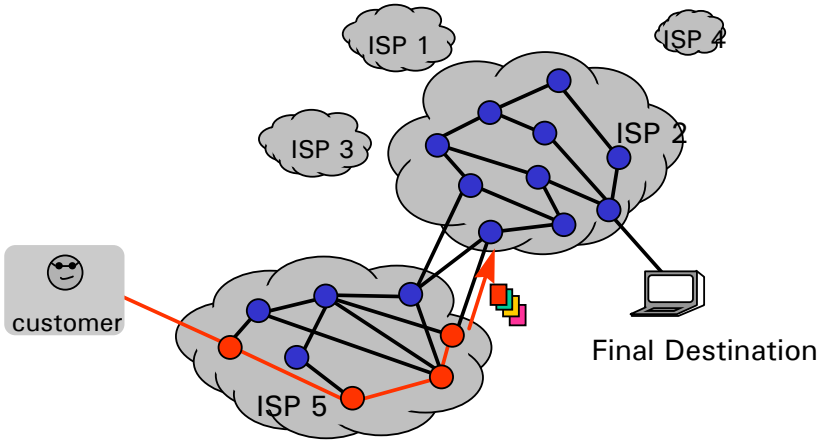
Customer finalizes the path selection by downloading the offer credentials.

Band-X Architecture (3)



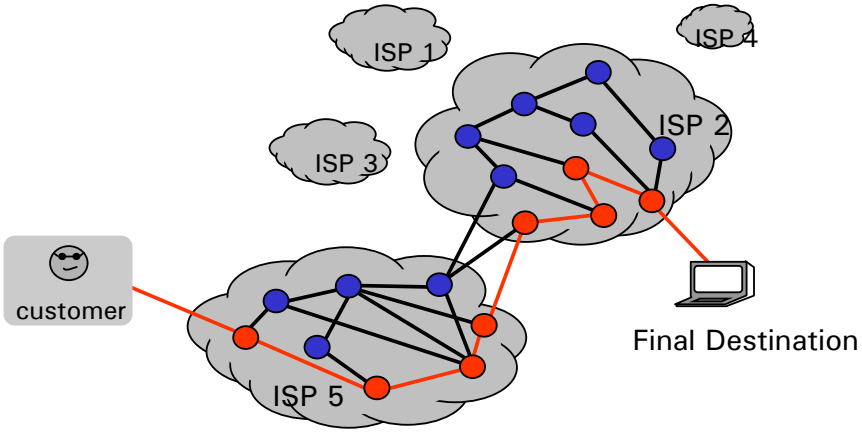
The customer issues a reservation request by sending the offer credentials collected from the BAND-X Clearing House along with a credit-worthiness credential issued by his or her credit institution.

Band-X Architecture (4)



- Each time the path crosses ISP boundaries, additional negotiations have to be carried out, to ensure that the next-hop ISP can be paid for passage.

Band-X Architecture (5)



- The path has now been established and normal communication over the purchased path can proceed.

Band-X Architecture (6)

- Operation of the Futures Market
  - In the spot market, offers have immediate effect.
  - In the Futures market, offers take effect in the future.
    - thus ISP must be informed in advance.
  - Carry out "notional" negotiation (same as spot market).
  - Reservation Credential(s) sent to the user.
  - When bandwidth is required (within the reserved period), user initiated reservation process.
    - in this case only the reservation credentials need be sent.

Implementation (1)

- Trust Management Framework
  - credentials contain public keys of *authorizer*, *licensee*, and *conditions*
  - Credential signed by the *authorizer*

(code that describes what is contained in the

```
Keynote-Version: 2
Local-Constants: ALICE KEY = "rsa-base64:MCgCIQGB0f8..."
      CG KEY = "rsa-base64:MIGJAo..."
Authorizer: CG KEY
Licensees: ALICE KEY
Conditions: app domain == "Band-X" && currency == "USD"
      && &amount < 5.01 && date < "20040324" -> "true";
Signature: "sig-rsa-sha1-base64:QU6SZtG9R3IXXAU9vRDBgu..."
```


Implementation (2)

- Trust Management Framework
  - Each entity trusts itself.
    - basic policy allows other entities to be trusted (conditionally)
    - additional credentials allow this trust to be extended (conditionally).
  - For a request to be granted it must be consistent with existing policy.
    - otherwise the request must supply credentials to extend the policy.
    - if not, the request will be denied.
  - Keynote library allows credentials to be verified and integrated into the policy automatically.

Problems

- Overbooking
  - ISPs do not know in advance how many offers will be exercised
- Loss of Quality
  - What happens if a link fails or if a provider fails to deliver on their promises
- Revocation
  - What if one or more actors change their minds?

Conclusions

- Model accommodates both “instant” purchases of bandwidth and advanced purchases
  - ISPs can plan ahead their resource allocation strategies
  - ISPs can get better prices for unused capacity rather that letting it go at Best-Effort prices.
- The entire protocol is efficient requiring only a few exchanges between a buyer and various sellers to effect a reservation.
- An existing reservation protocol (RSVP) is used for the reservation aspect of a BAND-X transaction.
  - BAND-X system can be deployed with minimum disruption.

Conclusions

- Credit Institution(s) link buyers and sellers
  - transactions can take place between buyer and seller without previous business relationship.
  - Allows bandwidth market to work freely with the buyer being able to select the seller offering the best value for money.
  - Model suitable to wireless environments (*e.g.,* a WiFi network in an airport) where mobile users cannot be expected to establish business relationships with the ISPs they use.
- Keynote-based micro-payment framework makes entire system efficient and scalable.

Conclusions

- The BAND-X model allows the presence of multiple entities for each role (*i.e.,* we can have multiple Credit Institutions, Clearing Houses, buyers and sellers) operating within a single market. This increases the competition and overall reliability of the entire system