



Different Players @ Different Layers

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The Hourglass: A Simplified Model

- Application Layer: Applications use IP for connectivity
- The Network Access Layer: Components in the Network Access Layer deliver IP connectivity
- The IP Layer: provides a coherent mapping between the layers
(IP=Internet Protocol)



The Application Layer

- Applications are what the users care about
- Most people conceive the utility of the various applications as the Internet
 - E-mail and WWW are just two applications, albeit successful ones
- Games, business, voice and face communication



Players @ Application Layer

- Provide services to those connected to the Internet
- IP allows people and/or devices to be both the client and the producer of services
- Applications providers can be independent from the Internet Service Providers
- Application providers can operate independently

Unlimited Possibilities

- New applications are conceived, built and deployed almost daily
 - Some proprietary, some have open standards
 - Classical Client-Server
 - Web 2.0 (user driven content)
 - peer 2 peer (the client is the server is the client)
- IPTV, the Internet of things, voice, face and gesture telephony....
- The imagination is the limit: Just Do It!

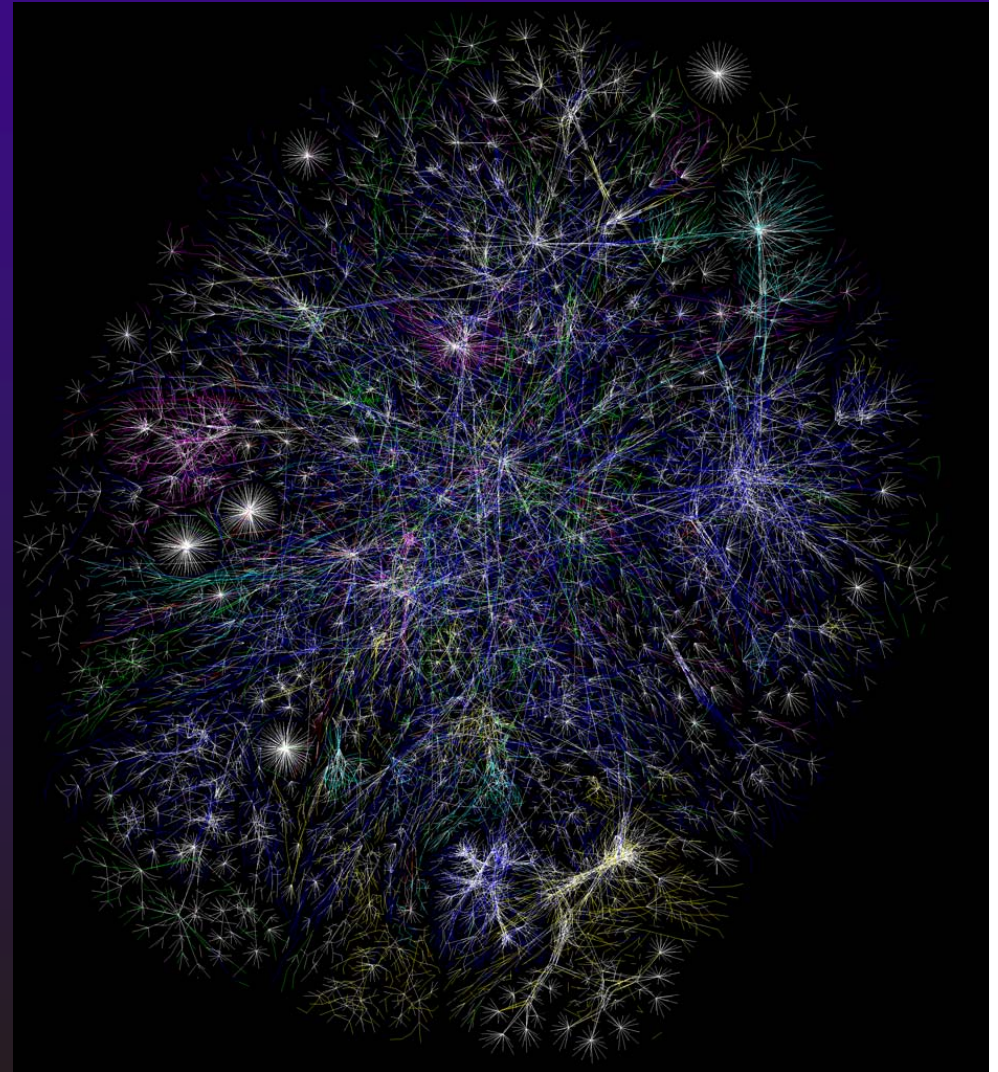
Network Access Layer



- The layer that provides the IP to the customers
- The Internet is made up out of many independently operated networks that all provide some level of network access
- The network exchange IP packets between each other

A wealth of Networks

- Internet is made up of several tens of thousands of autonomous networks
- Each network makes different operational choices
- Each network serves a different market



Players @ Network Layer



- Property: move IP packets
 - Through Radio, Fiber, or Copper
- Various Players serve a variety of different markets
 - Domestic, enterprise, and government customers
 - In densely populated and sparsely populated areas
 - Global (trans-oceanic transit) or local (access networks)

How many networks make one Internet?

- The independent networks operate autonomously.
- Networks exchange IP packets
- Traffic Exchange is based on agreements between directly connecting networks
- No need for all networks to have agreements with all other networks

Routing: collaborative glue between networks

- Deliver packets to a neighboring network that is closer to the packets' destination
- Routing will take care of the rest
- The path of the packets through the network is dynamic and can adjust to failures
- Interconnection over private links or at Internet Exchange Points

Why the Internet works: Application perspective

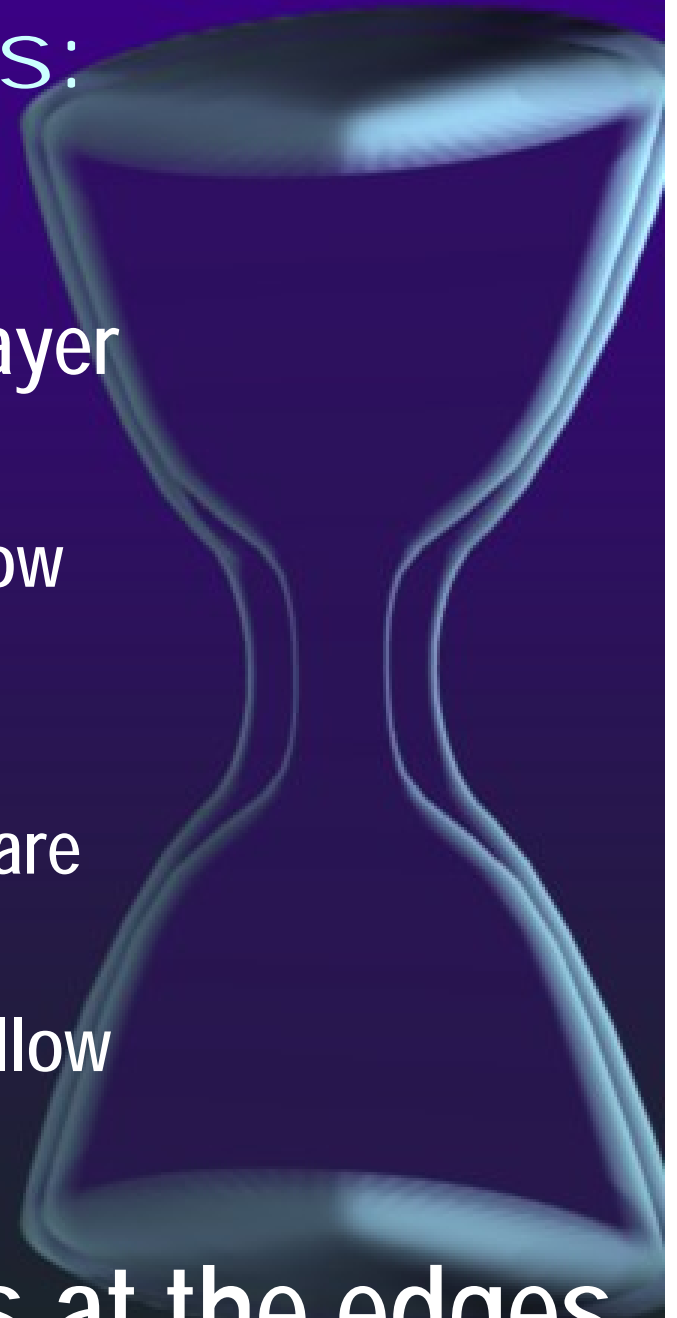


- Because the Application deals with IP
 - The Internet is a monolithic cloud to the Application
 - An application pushes its data to the IP layer in a standard way.
 - At the other side of the Internet the Application's counterpart will see the data appear.

End-To-End

Why the Internet works: Network perspective

- Because the Network Access Layer deals with the IP Layer
 - The network does not need to know about Applications above IP
 - The network does not need to be modified when new Applications are developed
 - The network can be modified to allow for different carrying technology



The network intelligence is at the edges

Why the Internet Works: Collaboration

- Standards Organization
- Resource allocation and assignment
- Registry maintenance
- Open and Bottom-Up



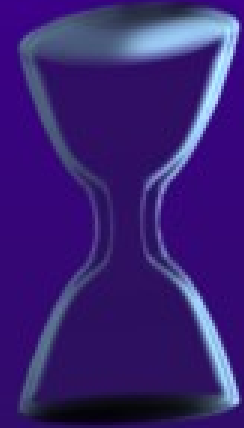
Interaction between the Network and Application Layers

- Applications drive capacity demand
- Network enables new applications to be deployed

- However forcing applications to know about the network or the network to know about applications has shown to be problematic

QoS as example of problematic interaction

- Quality of Service: Signaling application traffic needs to the network are not trivial
 - Network core would need to know about quality demands of applications
 - Possible within individual networks but not across multiple networks
 - Forcing the Network to know about applications may limit the possibilities of innovation in the application layer



Take away

- The Application Layer provides services to users
 - The imagination is the limit
 - New 'players' enter the market all the time
- The Network Access is provided by a large number of 'players'
 - Dynamic, evolving, collaborative where needed, and competitive elsewhere.

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