Project Related with Internet Indirection Infrastructure (i3)

- Goal: provide an uniform abstraction for basic communication primitives:
  - Unicast
  - Multicast
  - Anycast

- Next: overview of i3
Motivations

- Today’s Internet is built around a point-to-point communication abstraction:
  - Send packet “p” from host “A” to host “B”
- This abstraction allows Internet to be highly scalable and efficient, but…
- … not appropriate for applications that require other communication abstractions:
  - Multicast
  - Anycast
  - Mobility
  - …
Why?

- Point-to-point communication abstraction implicitly assumes that there is one sender and one receiver, and that they are placed at fixed and well-known locations.
  - E.g., a host identified by the IP address 128.32.xxx.xxx is most likely located in the Berkeley area.
Key Observation

- All previous solutions use a simple but powerful technique: *indirection*
  - Assume a *logical* or *physical* indirection point interposed between sender(s) and receiver(s)

- Examples:
  - IP multicast assumes a logical indirection point: the IP multicast address
  - Mobile IP assumes a physical indirection point: the home agent
Our Solution

- Add an efficient indirection layer (IL) on top of IP
  - Transparent for legacy applications
- Use an *overlay* network to implement IL
  - Incrementally deployable; don’t need to change IP
Internet Indirection Infrastructure

- Change communication abstraction: instead of point-to-point, exchange data by **name**
  - Each packet is associated an identifier ID
  - To receive a packet with identifier ID, receiver R maintains a trigger (ID, R) into the overlay network

![Diagram showing the concept of Internet Indirection Infrastructure](image-url)
Service Model

- Best-effort service model (like IP)
- Triggers are periodically refreshed by end-hosts
- Reliability, congestion control, and flow-control implemented at end-hosts
Mobility

- Host just needs to update its trigger as moves from one subnet to another
- Both sender and receiver can be mobile
- Can eliminate the “triangle routing problem”
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Multicast

- Unifies multicast and unicast abstraction
  - Multicast: receivers insert triggers with the same identifier
- An application can dynamically switch between multicast and unicast
Composable Services

- Use a stack of IDs to encode the successions of operations to be performed on data (e.g., transcoding)

- Advantages
  - Don’t need to configure path
  - Load balancing and robustness easy to achieve
Composable Services (cont’d)

- Both receivers and senders can specify the operations to be performed on data
Anycast

- Generalize the matching scheme used to forward a packet
  - Until now we assumed exact matching
- Next, we assume:
  - Exact matching on the most significant $l$ bits of ID
  - Longest prefix matching on the remaining bits (ID size = $m$)
Anycast (cont’d)

- Anycast is simply a byproduct of the new matching scheme
  - Each receiver in the anycast group inserts IDs that differ only in the last \( l-m \) bits
Anycast (cont’d)

- Highly flexible: the least significant $l-m$ bits of ID are application specific
- Two examples:
  - Load balancing
  - Proximity
Idea 1: Load Balancing

- **Assumptions:**
  - $N$ servers of capacity $C_i$, $1 \leq i \leq N$
  - $M$ clients downloading files from these servers

- **Goal:** come up with an algorithm to insert triggers and set up their identifiers such that to balance the load in the presence of server failures
Idea 2: Multicast

- Problem: triggers with the same identifiers are stored at the same server → not scalable
- Problem: extend $i3$ infrastructure to support large scale multicasts
Idea 3: Transcoding Application

- Design a transcoding application
  - From one video format to another (e.g., MPEG → H.263), or
  - From one data format to another (e.g., HTML → WML)
- Note: the goal of the project is not to design the transcoder, but to demonstrate the service composition function
Idea 4: Migrate-able End-to-End Protocols

- Modify TCP such that it is possible to change the receiving machine in the middle of the transfer!
- A and B open a TCP connection (A receiver; B source)
- A changes to A’
- B continue to send data to A; without creating a new connection
- Challenge: transparently transfer the receiver state from A to A’
Idea 5: $i^3$ in Sensornets

- Design and implement $i^3$ in Sensornets
- Challenge: there is no underlying point to point communication in sensornets
Other Project Ideas
Idea 6: Reducing (elimination) Multicast State in Routers

- Today each router maintain state for each multicast group that has traffic traversing it
- Problem: state is hard to maintain and manage → not scalable
- Extreme solution: maintain all receiver addresses in each packet
  - Routers don’t need to maintain any state, but
  - Packet headers can become very large → huge overhead
- Solution: design an algorithm in between
  - Maintain some state in routers and some in packets
- Note: you can think either at the IP or application layer
Idea 7: A Self-Organizing Overlay Multicast Tree Algorithm

- Goal: design and simulate a self-organizing multicast tree algorithm for overlay networks
- Algorithm idea: have overlay nodes decide to add/collapse branches in the multicast tree
- Example:
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- Example:
Forwarding in Low Energy Wireless Networks

- Problem: each node cannot afford to remain ON all the time
  - a node can communicate/receive data only when it is ON
- Two nodes can communicate only when both of them are simultaneously ON
- A node stores a packet in transit until it finds the next hop ON
Ideas 8 & 9

- Assume routing tables are known
- Assume that each node is independently switching between ON and OFF states

Idea 8:
- Study the tradeoff between the fraction of time a node is ON and the time to deliver a message and the amount of storage required by a node

Idea 9:
- Design a self-synchronization algorithm and study its properties (i.e., a distributed algorithm that will result in all nodes being ON at the same time)
Idea 10: Implement Round Robin at the Application Layer

- Problem: flow isolation (UDP can kill TCP)

- Solution outline:
Idea 11: Receiver-Controlled Cooperative Sharing

- You control the downstream router or the end host
- You want to control the bandwidth allocation policy
  - Manipulate TCP packets to adjust the sender’s transmission rate
Next Step

- You can either choose one of the projects we discussed during this lecture, or come up with your own.
- Pick your partner, and submit a one page proposal by February 13. The proposal needs to contain:
  - The problem you are solving
  - Your plan of attack with milestones and dates
  - Any special resources you may need