Large-scale Edge Services: 1 MLoC, 1M devices, 1 week

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Novel Classes of Edge Services

• Need to identify potential classes of applications before discussing challenges in detail

• My “short” list (but many more)
  – Applications and services that span and migrate across multiple access networks (e.g., handoff between GSM and WiFi)
  – Sensors integrated into the network
  – Point-to-Point comm: VoIP, IM, SMS
  – Broadband comm: Blogging, video/audio IM
  – Information retrieval/search
  – Information management
  – Web services
  – Future applications…
Concrete Grand Challenge

• Develop and deploy a 1MLoC application in one week on 1,000,000 nodes
  – Must be secure, robust against network and end node failures, reliable, highly available, work over asymmetric/wireless networks, …
  – Could be 1,000,000 wireless PDAs, sensor nodes, cellular phones, …

• Must be easy and simple to experiment with and to evaluate resulting distributed application
  – As easy for others to evaluate 2 years from deployment with a new algorithm, as was original deployment time evaluation by developers
Challenges/Opportunities for Novel Edge Devices

• Many devices/user = many identities, devices, networks
  – Desire single ID model where information flows to reach user the way the user wants it
  – Person-level communication API across networks (higher than IP)
    • A “primitive” in a new Internet?
  – Goal is *Personal Mobility*
    • User controls how/when/where

• New Internet/IP all the way to the edge?
  – IP on every edge device or protocol adapters in the middle?
  – Universal connectivity or islands of connectivity?

• Security/Privacy
  – Yet another device vulnerable to attack
  – Lots of metadata being collected

• Common dev environment for distributed services (.NET?)
Potentially Any Network Services

• Distributed services should be accessible from anywhere
  – Ex: Google’s Voice Search and SMS Search by Phone

• Service Mobility
  – Migration of active services (e.g., a phone call) across network boundaries (GSM to WiFi)

• Endpoint Mobility
  – Migration of active services across devices (e.g., sensor mote tracking service)
Networking Protocol Challenges

• Cross-layer and cross-network services
  – $\uparrow$ Conveying status info (QoS) up from network/devices
  – $\downarrow$ Conveying service reqs (QoS) down from applications
  – $\leftrightarrow$ Conveying info across networks (GSM, WiFi, …)
  – Prediction services?

• Extensible XML versus IP hourglass
  – Extensibility means more info can be conveyed
  – IP hourglass simplifies implementation

• What should be pushed into a new Internet?
  – Command and control tools for apps and network
  – Reusable state mgmt, comm., comp., & coord. tools
Security and Privacy

• Identify useful primitives/information that the infrastructure can provide and collect
  – Ex: Packet-level authentication
  – Ex: Location (could be highly accurate)

• Many privacy and security challenges
  – Not just for location (Ex: “comm. patterns”)
  – Who “owns” data and can it be shared with others?
  – Who gets access to the data?

• Even if I opt-out, I can still be tracked if enough others record their interactions with me!
Testbed

• My “dream” testbed:
  – $O(1,000)$ “real” nodes
  – Each “wirelessly” connectable to $n \leq 1,000$ others (via remote controlled attenuators and delay loops?)
    • The ultimate plug panel
  – Automated process for controlling attenuators
  – Wireless equivalent of Emulab/DETERlab

• Experimenter’s Notebook
  – Captures all input parameters and cross effects
  – Validates results with variance model

• Seamless transition to widespread deployment
  – Same management/deployment tools