Centralize what you can, Distribute what you must

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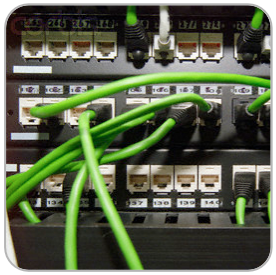



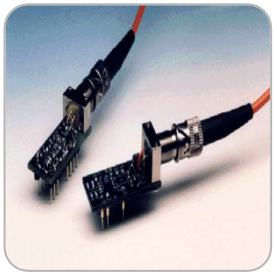

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Distributed Architectures

- Last decade networking research has focused in highly distributed architectures
- P2P, Distributed Networking Systems
- High availability, reliability, high performance

End Result

- The end result is the commoditization of Hardware equipment and reduction of related costs (CAPEX)
  - Distributed Cloud servers, Cheaper databases, Commoditizing routers, etc
- However, operational costs (OPEX), have not decreased at the same rate
- In fact, highly distributed architectures tend to increase operational costs
  - Human costs are harder to lower than technology costs

Operational Costs

- Usually account for a much higher cost than the actual equipment
- As CAPEX comes down, OPEX still remains very high
- the CLOUD helps replace CAPEX for OPEX and lower OPEX costs due to higher economies of scale
- Centralize what you can and distributed what you must
  - absorb traffic early, reliability, responsiveness, latency, etc.

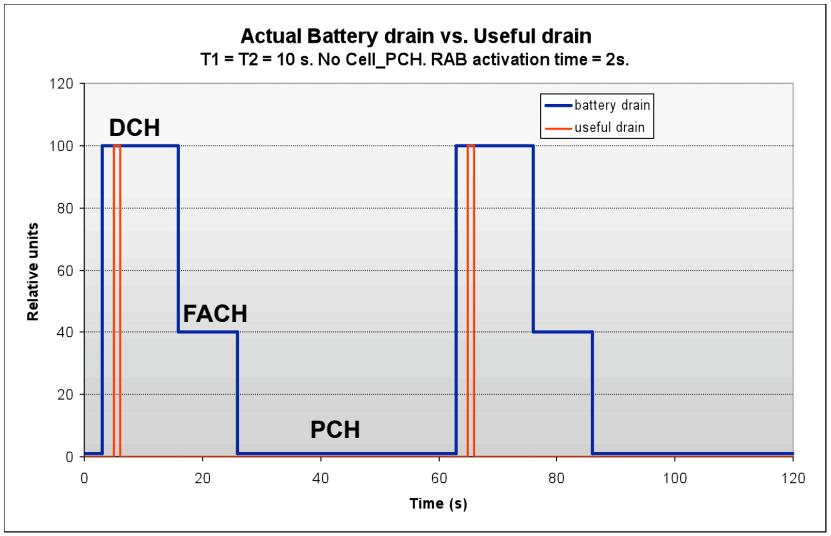
Cloud Benefits

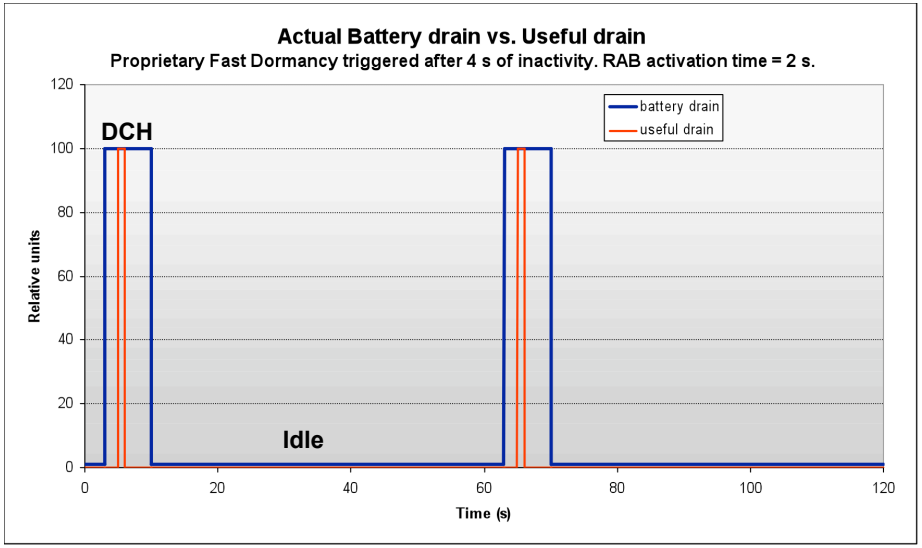
- Reduces OPEX
- Do it once and share
- Do it more coordinately
- Do it more efficiently

sample benefits for mobile cloud applications: more than offloading computation

1 Impact of Smart Phones on the network

- Signaling Problems: Fast Dormancy for battery savings



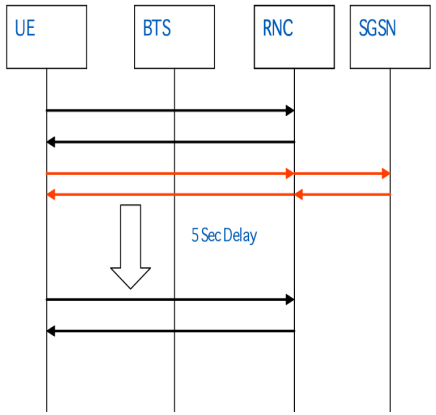


CELL_DCH: Dedicated Channel
CELL_FACH: Connected mode but Shared Channel
CELL_PCH: Mostly inactive radio. Radio Resource Control connection up.
Idle: Mostly inactive radio. no Radio Resource Control connection.

1 Impact of Smart Phones on the network

- Signaling Problems

Starting Data Session From Low Energy State (PCH state)

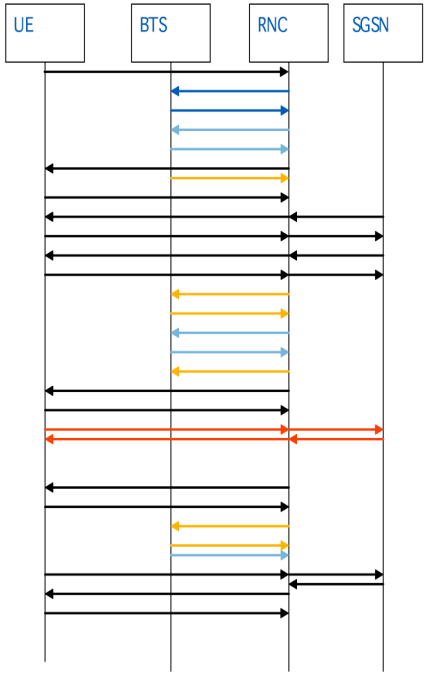


- All Data Transmitted on Iub User Plane

  Cell Update User Data
  Cell Update Accept RRC mode FACH
  User Data TCP Heartbeat packet
  User Data TCP Heartbeat packet Ack

- RRC State Change to Cell_PCH
  RRC State Change accept

Starting Data Session From Idle State



- Service Request (User Plane)
  RL Setup (CNBAP)
  RL Setup Complete (CNBAP)
  AAL2 Establish Request (AAL2 Sig)
  AAL2 Setup Complete (AAL2 Sig)
  RRC Connection Setup (User Plane)
  RL connection restore (DNBAP)
  RRC Connection Setup Complete (User Plane)
  Security Mode (User Plane)
  Security Mode Complete (User Plane)
  RAB Setup (User Plane)
  RAB setup complete (User Plane)
  RL Reconfi gure prepare (DNBAP)
  RL Reconfi gure Confi rm (DNBAP)
  AAL2 Reconfi gure (AAL2 Sig)
  AAL2 reconfi gure confi rm (AAL2 Sig)
  RL Commit (DNBAP)
  RB Reconfi gure
  RB Reconfi gure Complete
  User Data TCP Heartbeat packet (User Plane)
  User Data TCP Heartbeat packet Ack (User Plane)

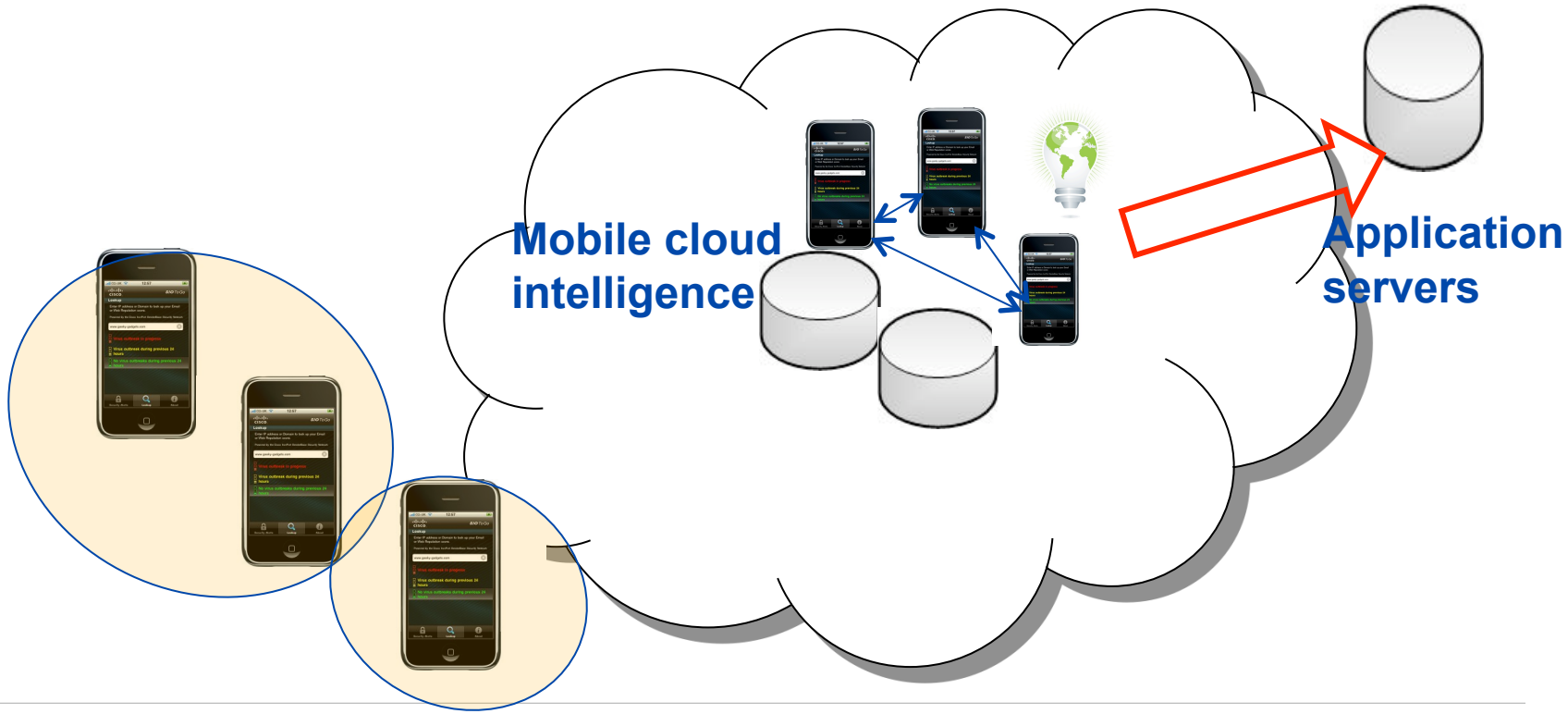
  RRC State Change to Cell_FACH (User Plane)
  RRC State Change accept (User Plane)
  RL release (DNBAP)
  RL link release complete (DNBAP)
  AAL2 reconfi gure confi rm (AAL2 Sig)
  RRC signalling bearer release request (User Plane)
  RRC Signalling bearer release (User Plane)
  RRC release complete (User plane)

1 Impact of Smart Phones on the network

- Massive rise in the amount of signalling on Radio and Core systems due to both chatty applications and device designs
- Saturated network elements (e.g. firewalls), due to uncoordinated connection management
- High number of unnecessary PPP context setup and releases

1 Can we run a full/partial virtual instance of each smartphone in the cloud (apps/firmware?)

- proxy a lot of the functionality, to save signaling and mitigate network impact
- share info and measurements across devices,
- coordinate device sync ups to avoid network peaks, wasting battery, or interfering with voice traffic



2 Battery efficient Ad-Hoc Data Sharing

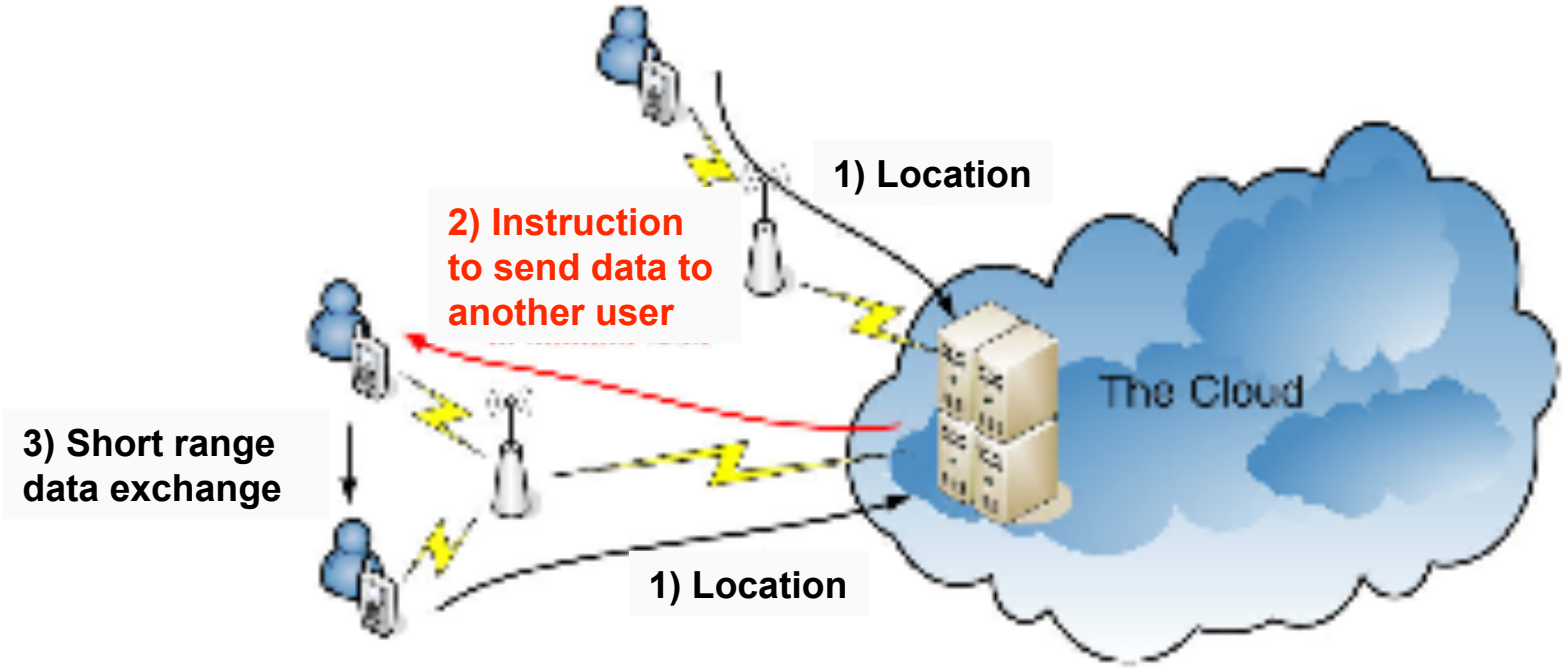
- By sharing location info and data content across devices using the cloud, one can predict nearby device and data presence better, coordinate short range local transfers and save energy

	Tput	Transfer (J/MB)	Idle (W)	Scan (W)	Range (m)
Cellular	Few kbps 100	100	0*	0*	500
Wi-Fi	11-54 Mbps	5	0.77	1.29	100
Bluetooth	700 Kbps	0.1	0.01	0.12	10

Ananthanarayan et al.'09

2 Battery efficient Ad-Hoc Data Sharing

- Centrally coordinating WiFi/Bluetooth wake up intervals, one can save energy and better predict sharing opportunities: Global View. Local view may see a disconnected graph, while global view may be able to see a connected one



Summary

- As hardware is more commoditized, Operational costs will dominate
- Cloud reduces OPEX by amortizing support/management costs over large number of applications
- Cloud also provides more intelligent services by aggregating global information and intelligently coordinating distributed actions
- **What to centralize, what to leave distributed? That is the question**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