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# Key Trends

- Client technology
  - devices: smart phones, tablets, sensors
- Big data
  - distributed and dynamic
- Privacy/trust
  - small circles
- Multiple DCs
  - global services

# Minnesota Cloud Research

- Eye towards cloud evolution
- Projects
  - **Nebula**
  - **Mobile cloud**
  - **DMapReduce**
  - Proxy cloud
  - Active cloud storage
  - Virtualization

# Big Data Trend

- Big data is distributed
  - earth science: weather data, seismic data
  - life science: GenBank, PubMed
  - health science: GoogleEarth + CDC pandemic data
  - web 2.0: user multimedia blogs
  - "everyone is a sensor"

- Cost in moving data to the cloud

# Big Data Trend: Nebulas

- Process data "close by"
  - fully and/or on-route to the central cloud
  - cost: save time and money
  - privacy (think: patient records, local google doc)

- Close by
  - network distance
  - trusted peers

# Example: Dispersed-Data-Intensive Services

- Data is geographically distributed
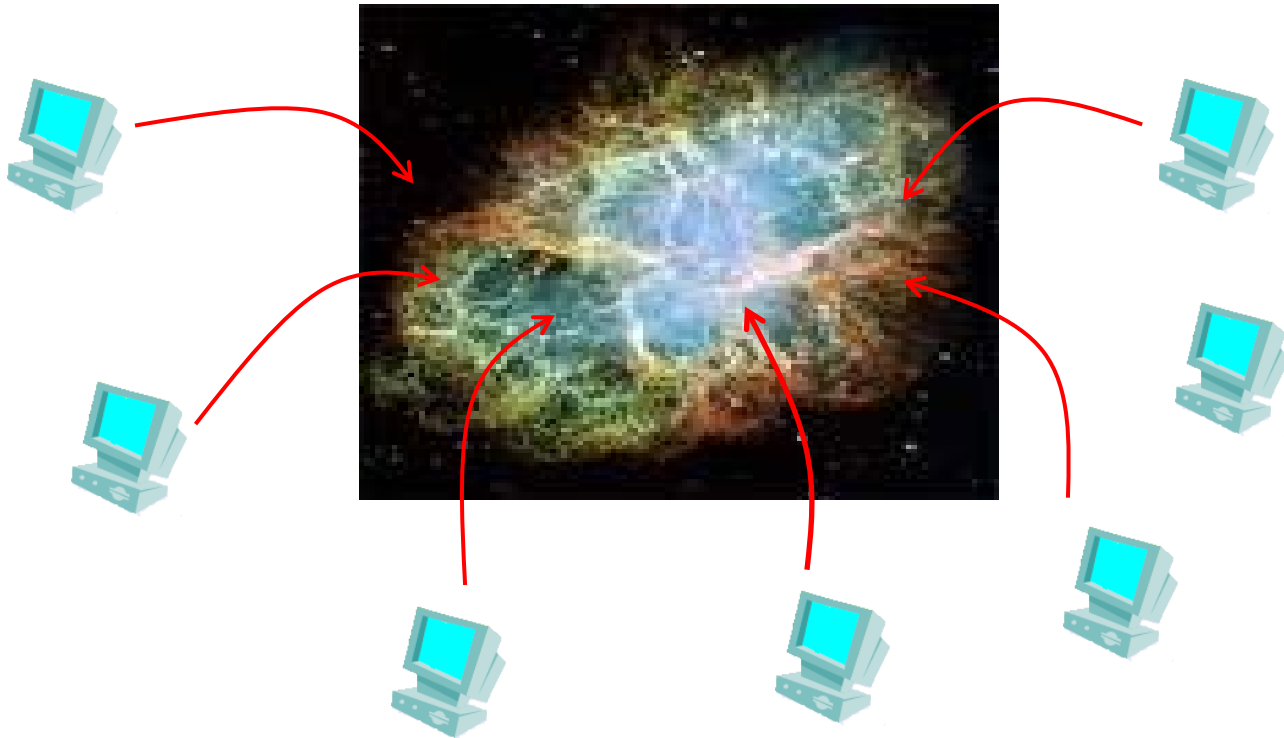  - Costly, inefficient to move to central location
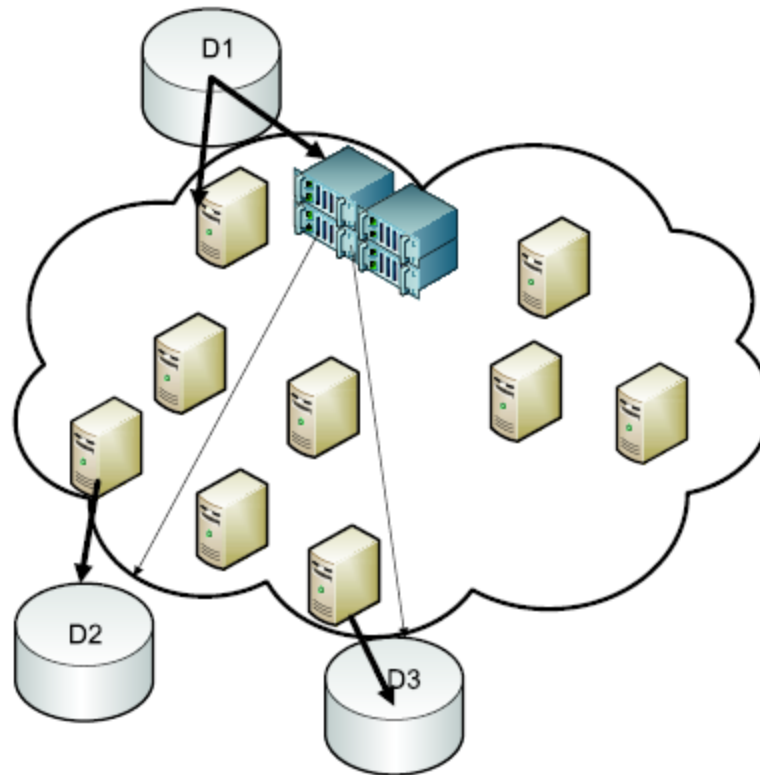
# Example Instance: Blog Analysis

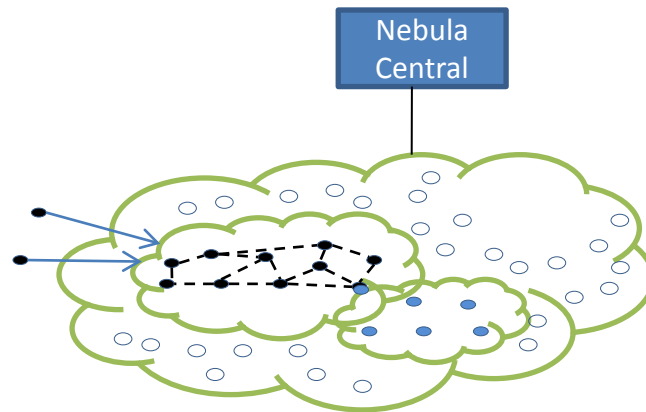blog1

blog2

blog3
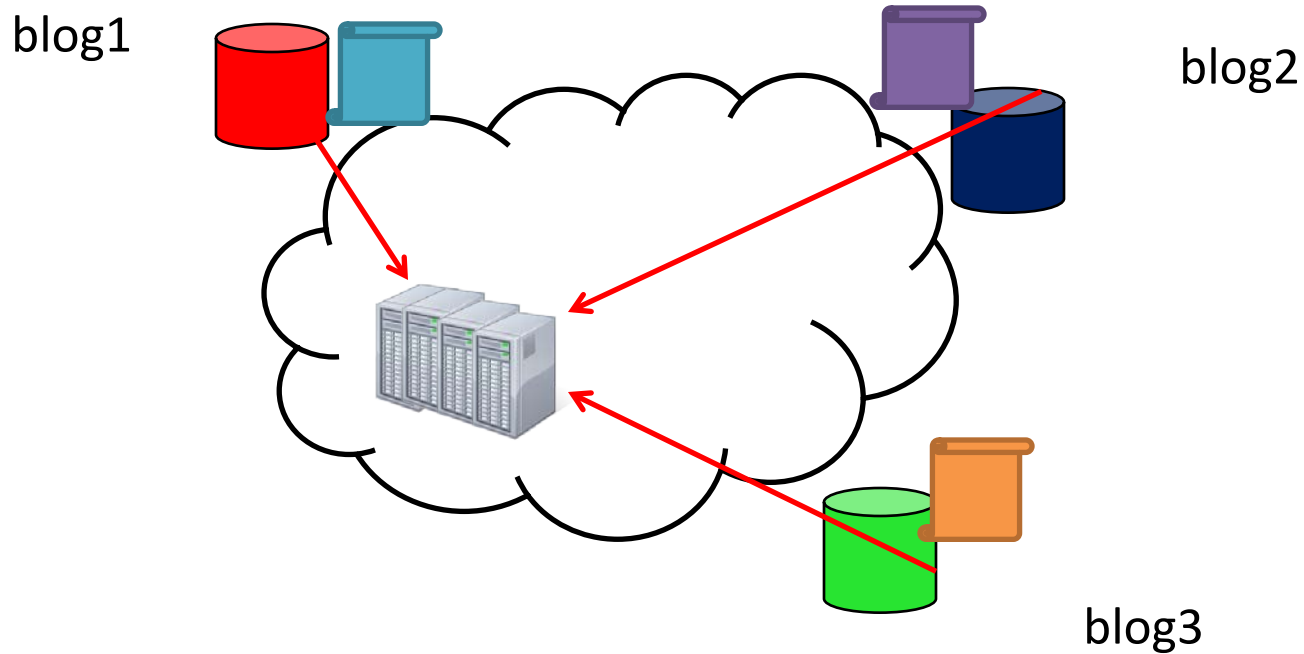
# Nebula

- Decentralized, less-managed cloud
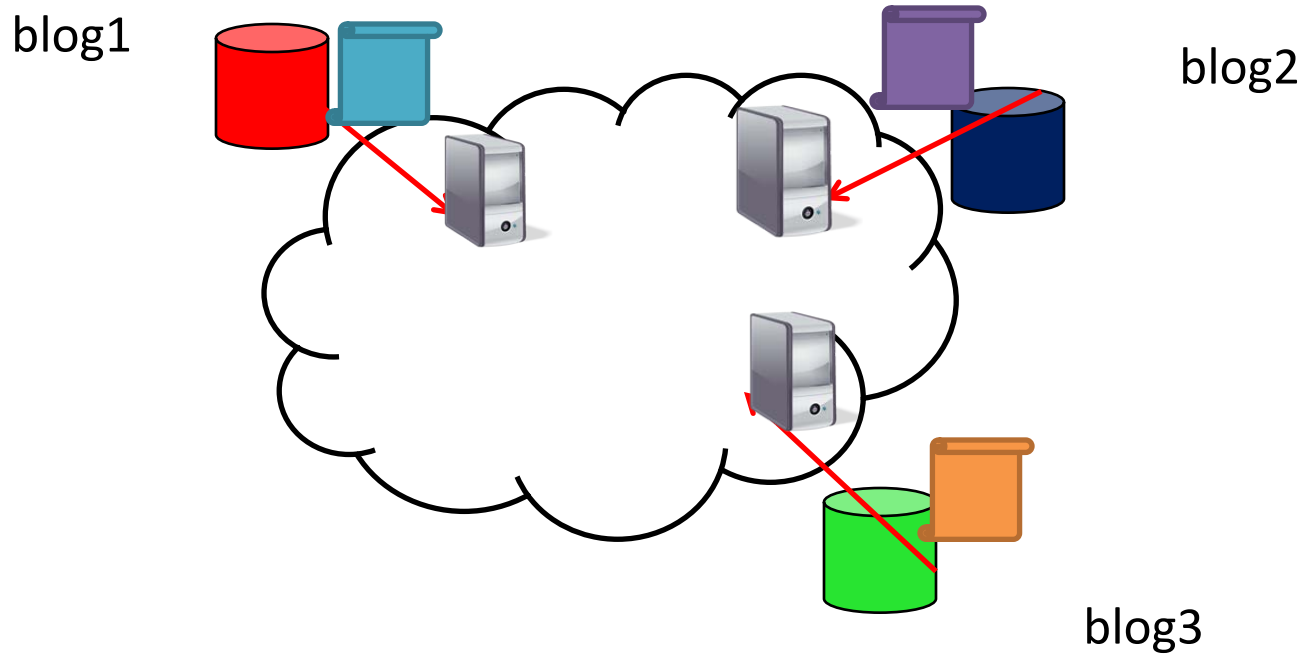  - dispersed storage/compute resources
  - low user cost
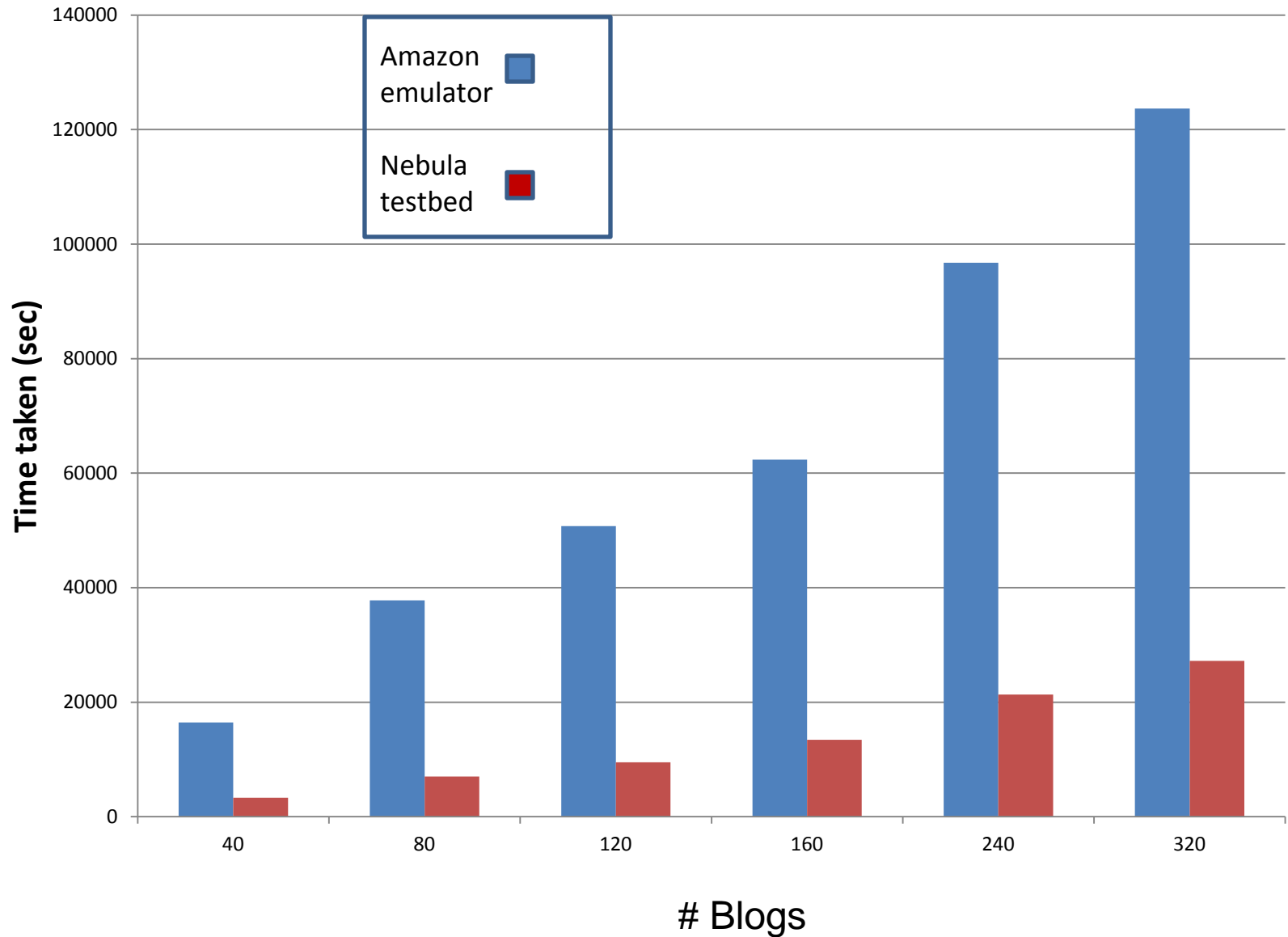
# Nebula: A New Cloud Model

- Make the cloud more "distributed"
  - exploit the rich collection of edge computers
  - volunteers (P2P, @home), commercial (CDNs)
  - enormous computing potential, network diversity
  - lower latency: "on demand", native client sandboxing

# Example: Blog Analysis

blog1

blog2

blog3

# Blog Results

# Current Status

- Prototype running on PlanetLab
  - Chrome browser clients + native client
  - Distributed data-store service
  - Network dashboard service

# Nebula Going Forward

- Organize Nebulas
  - around trusted peers
  - social groups
  - communities of interest
  - local resources

- Nebula + commercial cloud
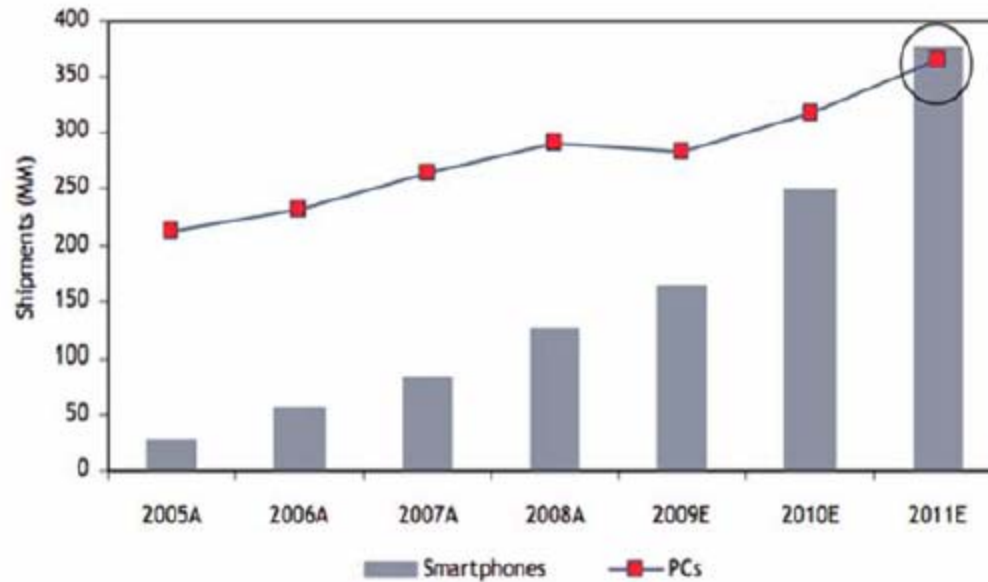  "use the edge opportunistically"

# Nebula Going Forward

- Hybrid paradigms
  - early discard
  - fan-in
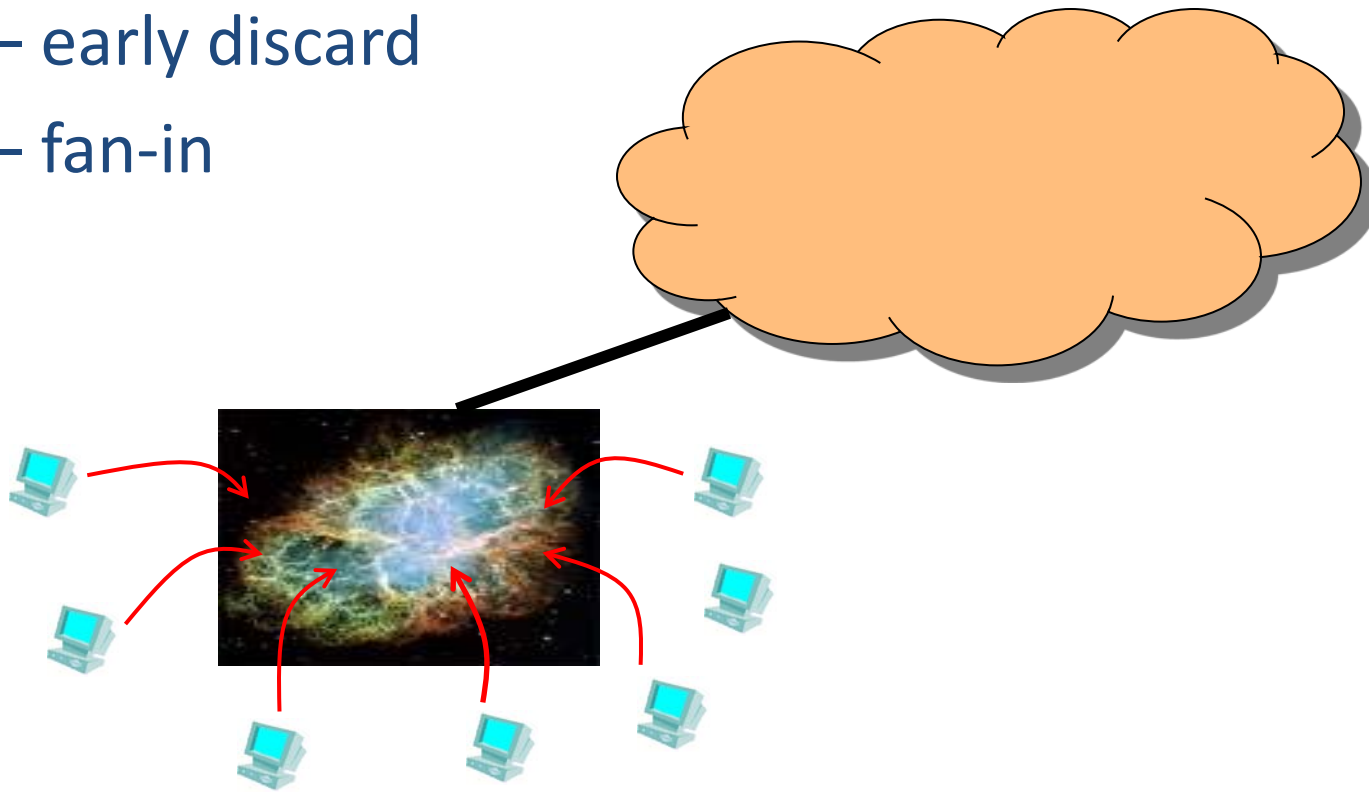
# Mobility Trend: Mobile Cloud

*PCs = ( Desktops + Laptops + PDAs )*



Source: RBC Capital Markets estimates

# Mobility Trend: Mobile Cloud

- Mobile users/applications: s-phones, tablets
  - resource limited: power, CPU, memory
  - applications are becoming ↑ sophisticated


- Improve mobile user experience
  - performance, reliability, fidelity
  - tap into the cloud **dynamically** based on current resource state, preferences, interests, privacy

# Cloud Mobile Opportunity

- Dynamic outsourcing
  - move computation, data to the cloud dynamically

- User context
  - exploit user behavior to pre-fetch, pre-compute, cache

- Multi-user sharing
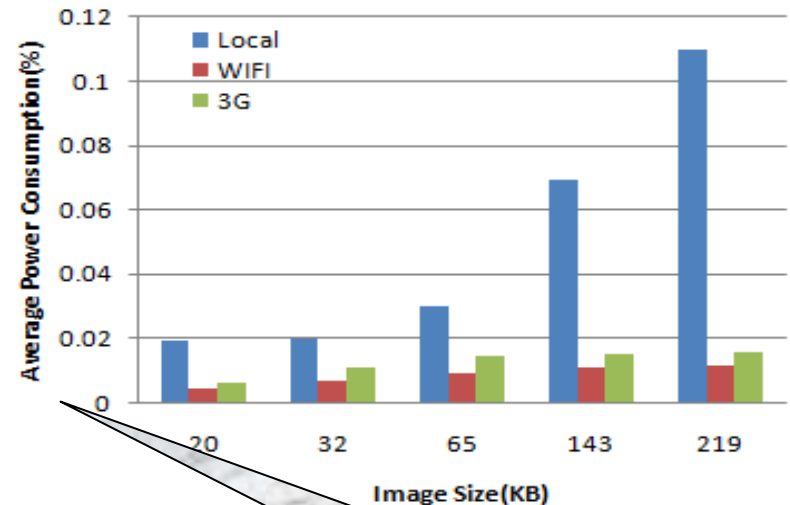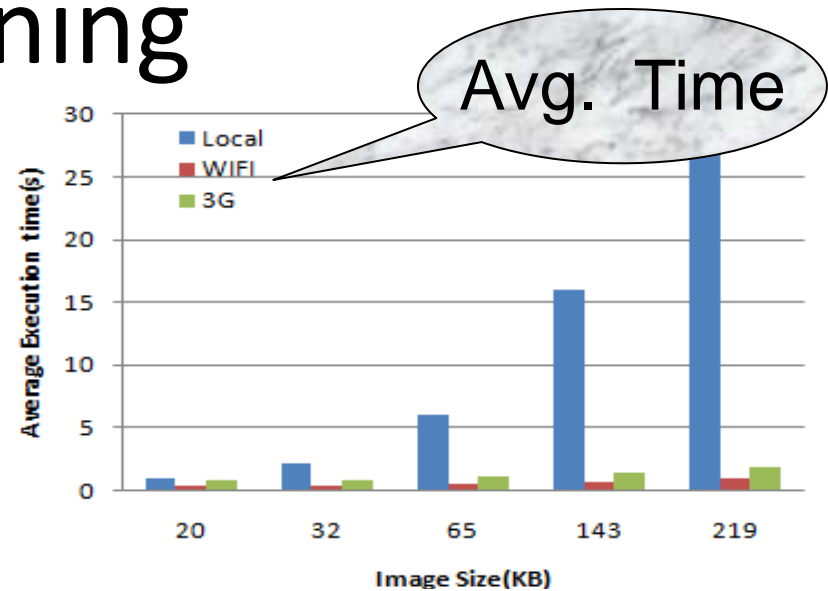  - discover implicit cloud sharing based on interests, social ties

# Outsourcing

- Partitioning across (Mobile <-> Cloud)
  - local data capture + cloud processing
  - images/video, speech, digital design, aug. reality
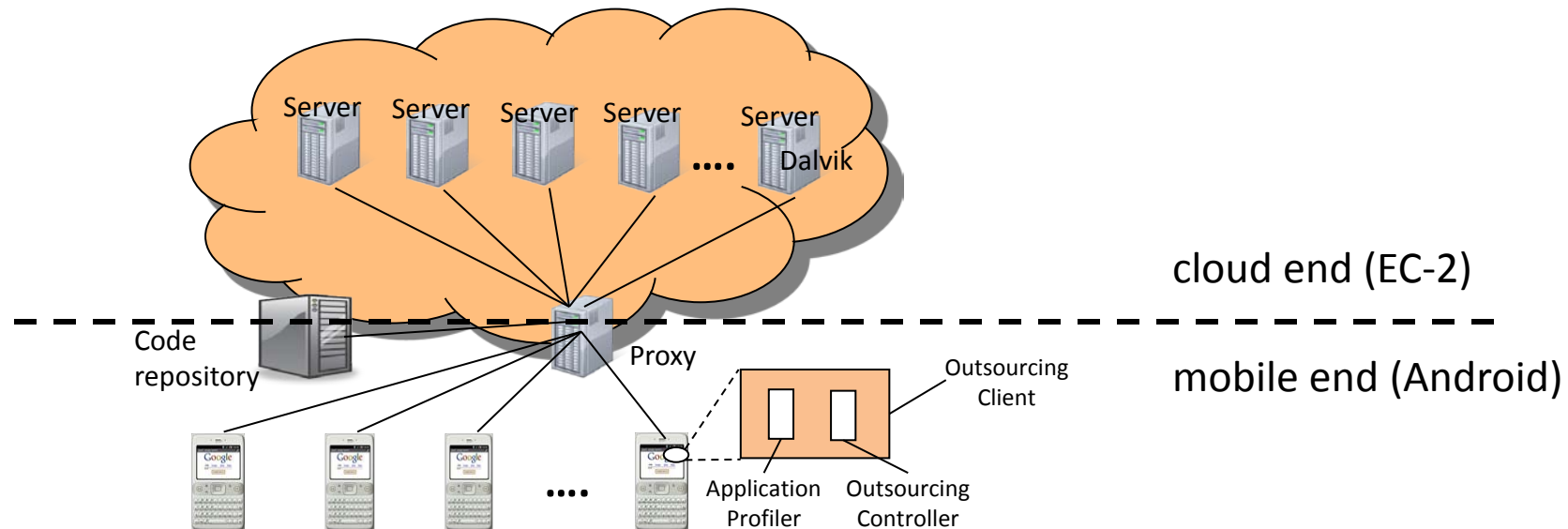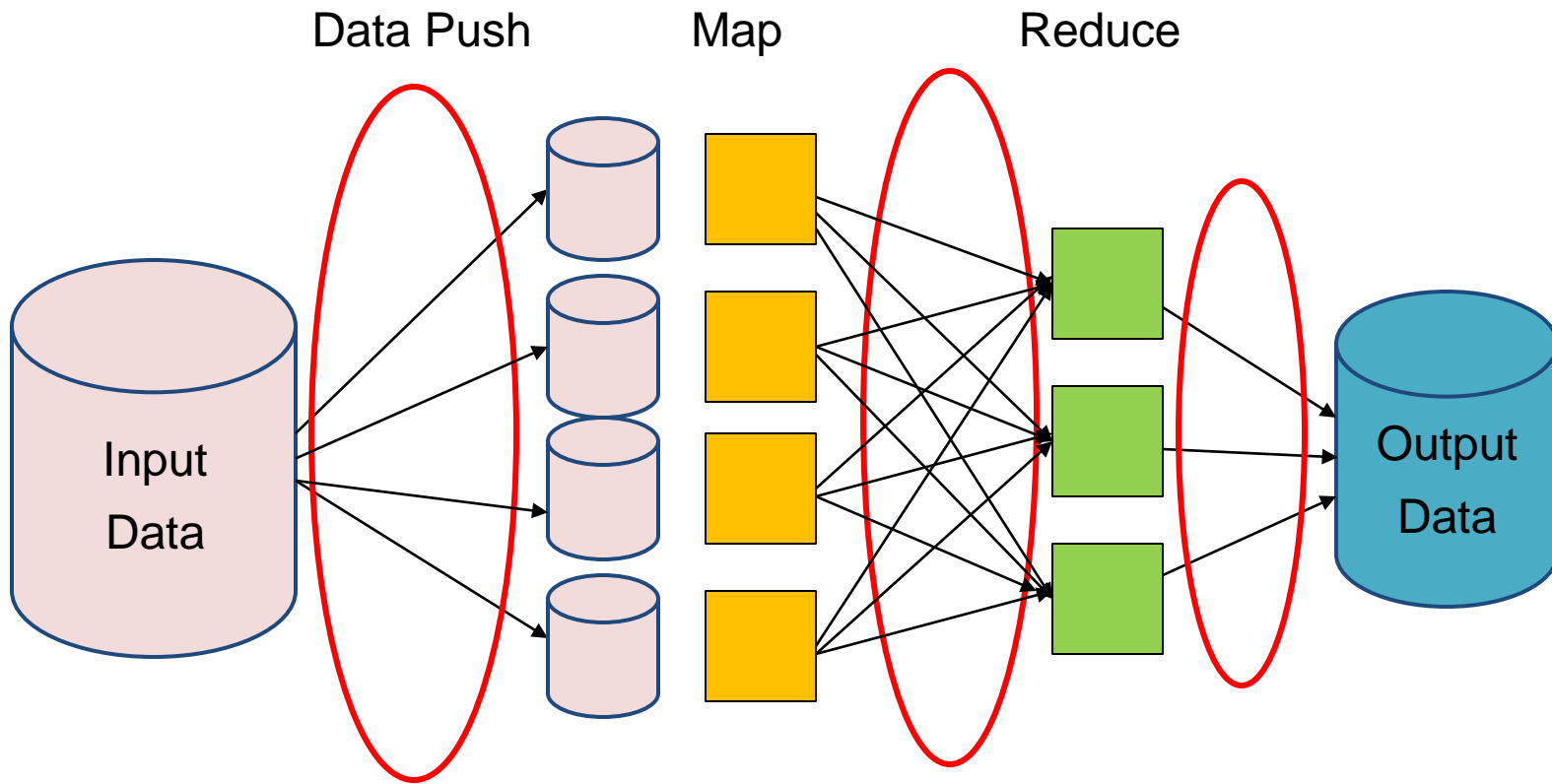
# Experimental Results -Image Sharpening

- Response time
  - both WIFI & 3G
  - up to 27× speedup

- Power consumption
  - save up to 9× times
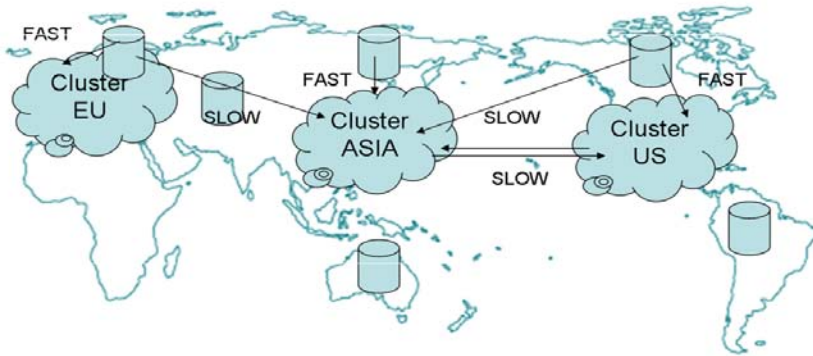


Avg. Time



Avg. Power

# Current Work

- Optimizations
  - User patterns => speculation, aggregation, data reduction


- Cloud-side
  - Cross-user patterns => sharing: VM provisioning, data placement, data re-use

# Big Data Trend + Multi-DCs: DMapReduce
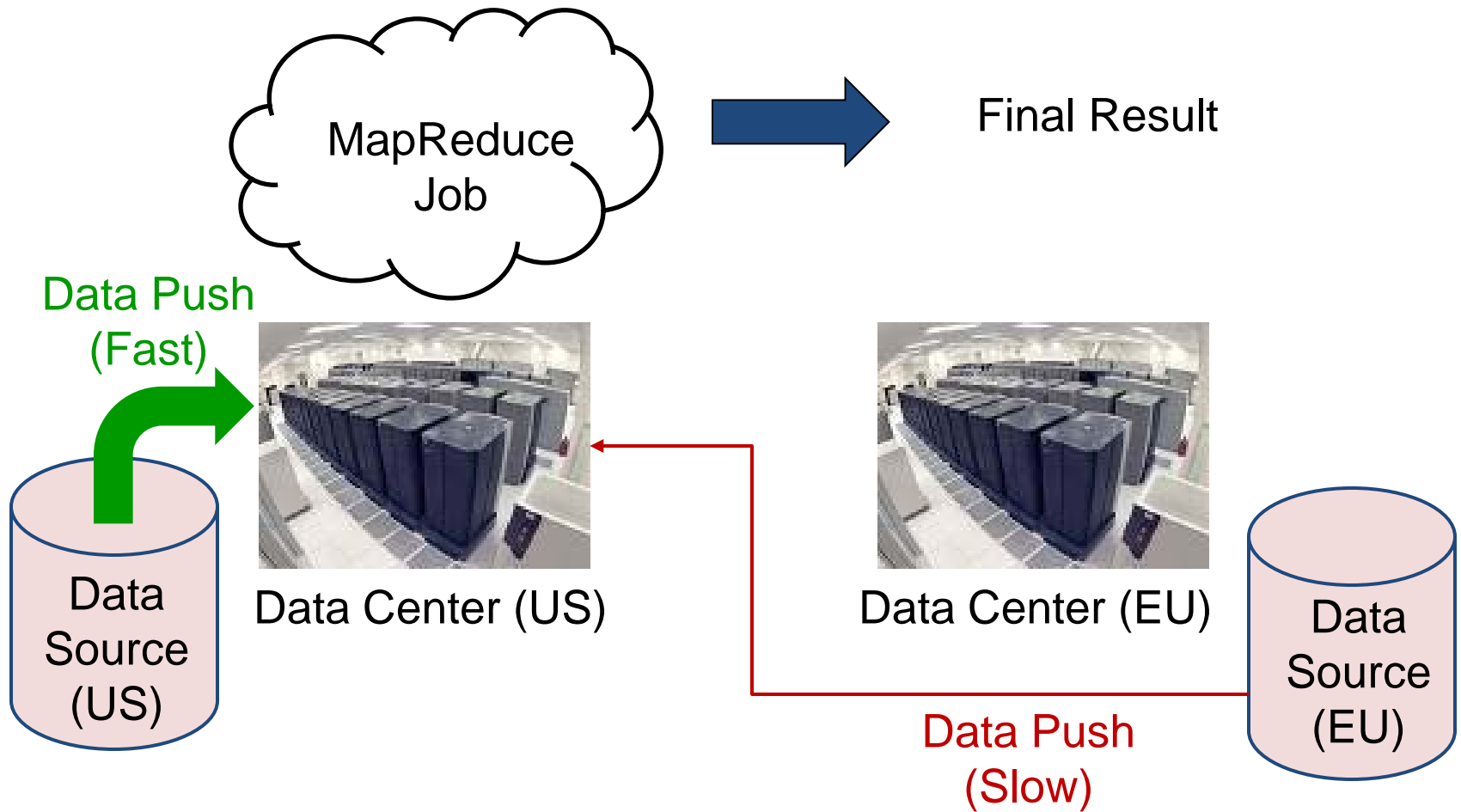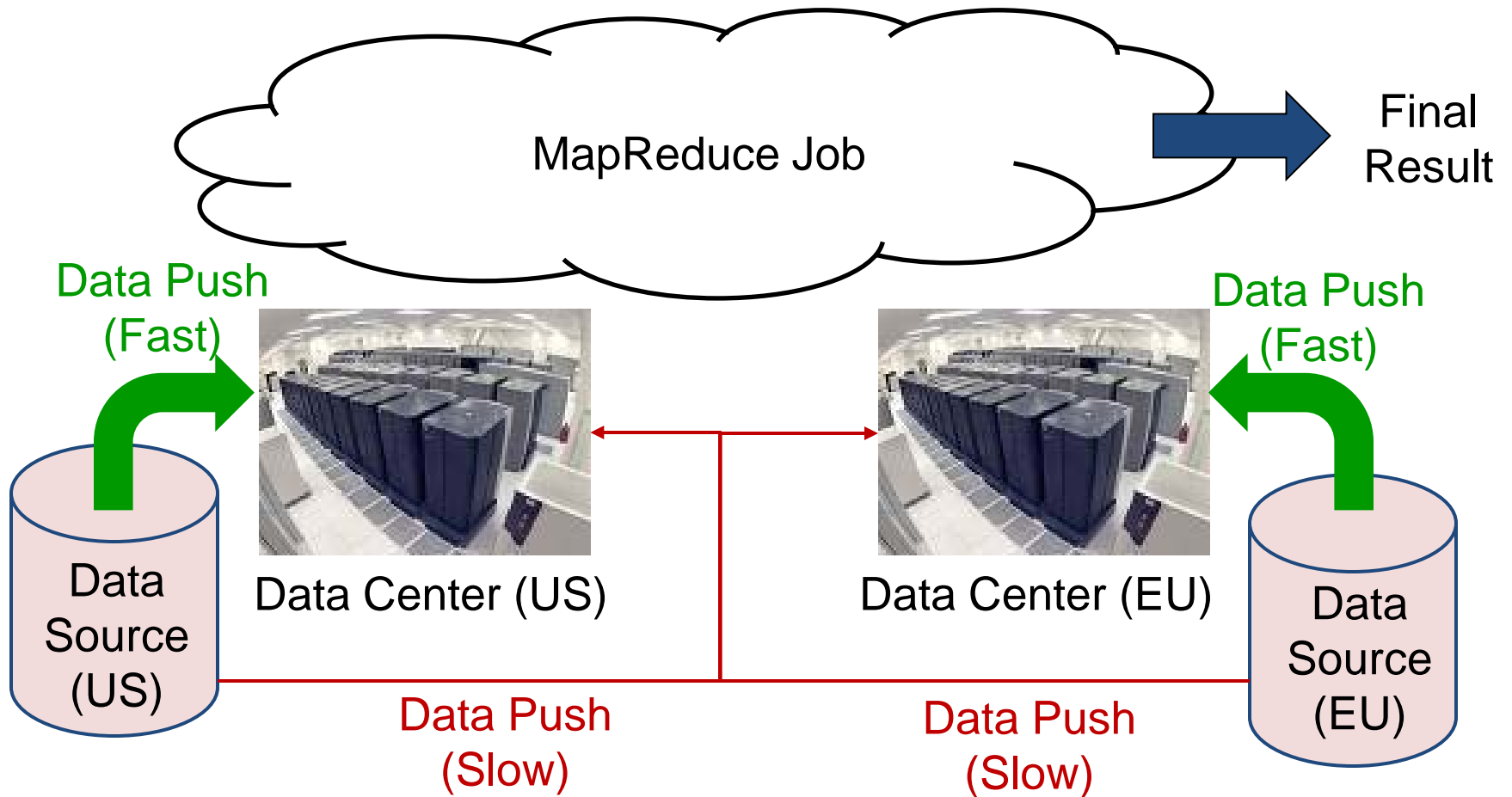
# Wide-Area MapReduce



Big data is distributed

– earth science: weather data/seismic data

– life science: GenBank/PubMed

– health science: GoogleEarth /pandemic data

– web 2.0: user multimedia blogs

- Data in different data-centers

- Run MapReduce across them

- Data-flow spanning wide-area networks
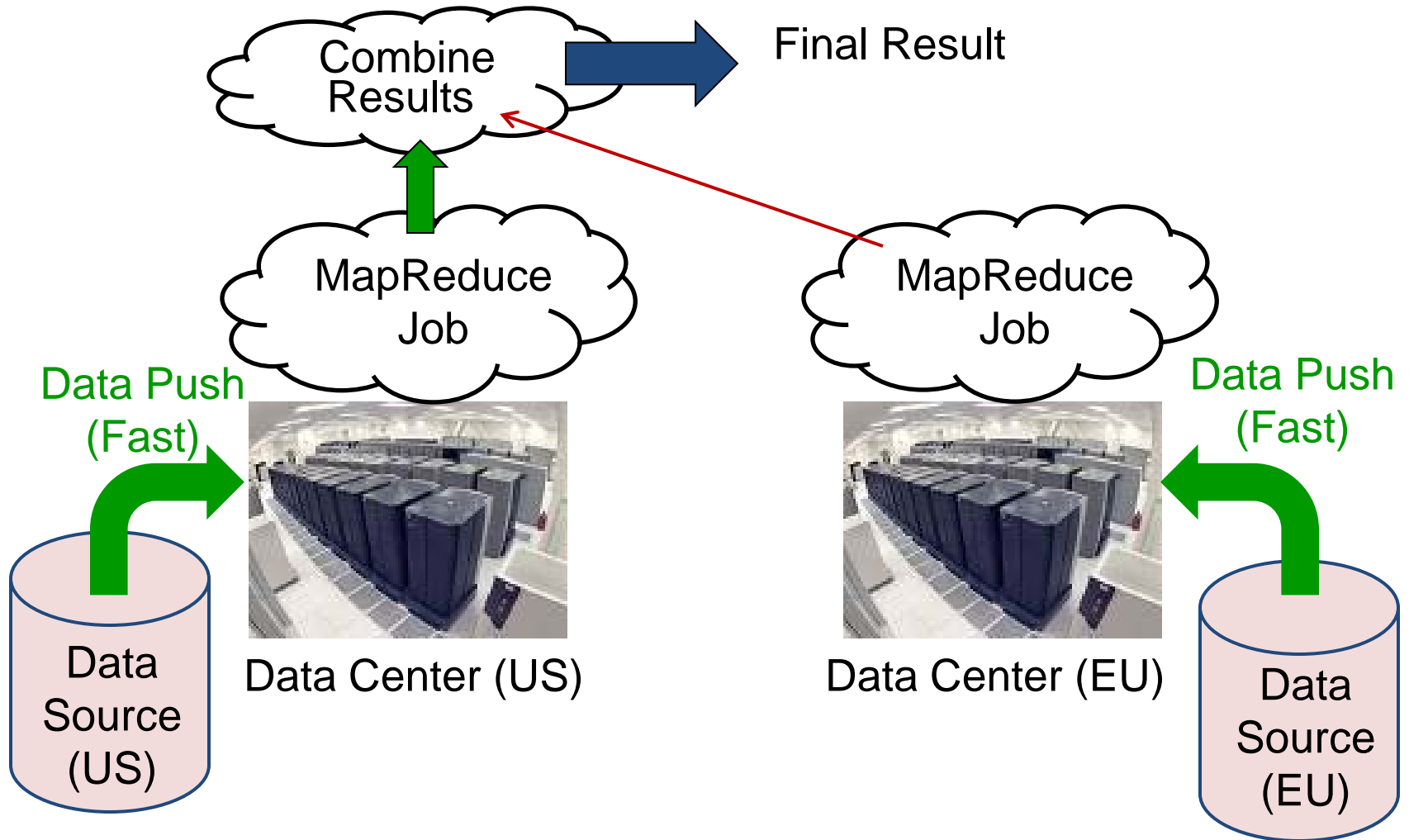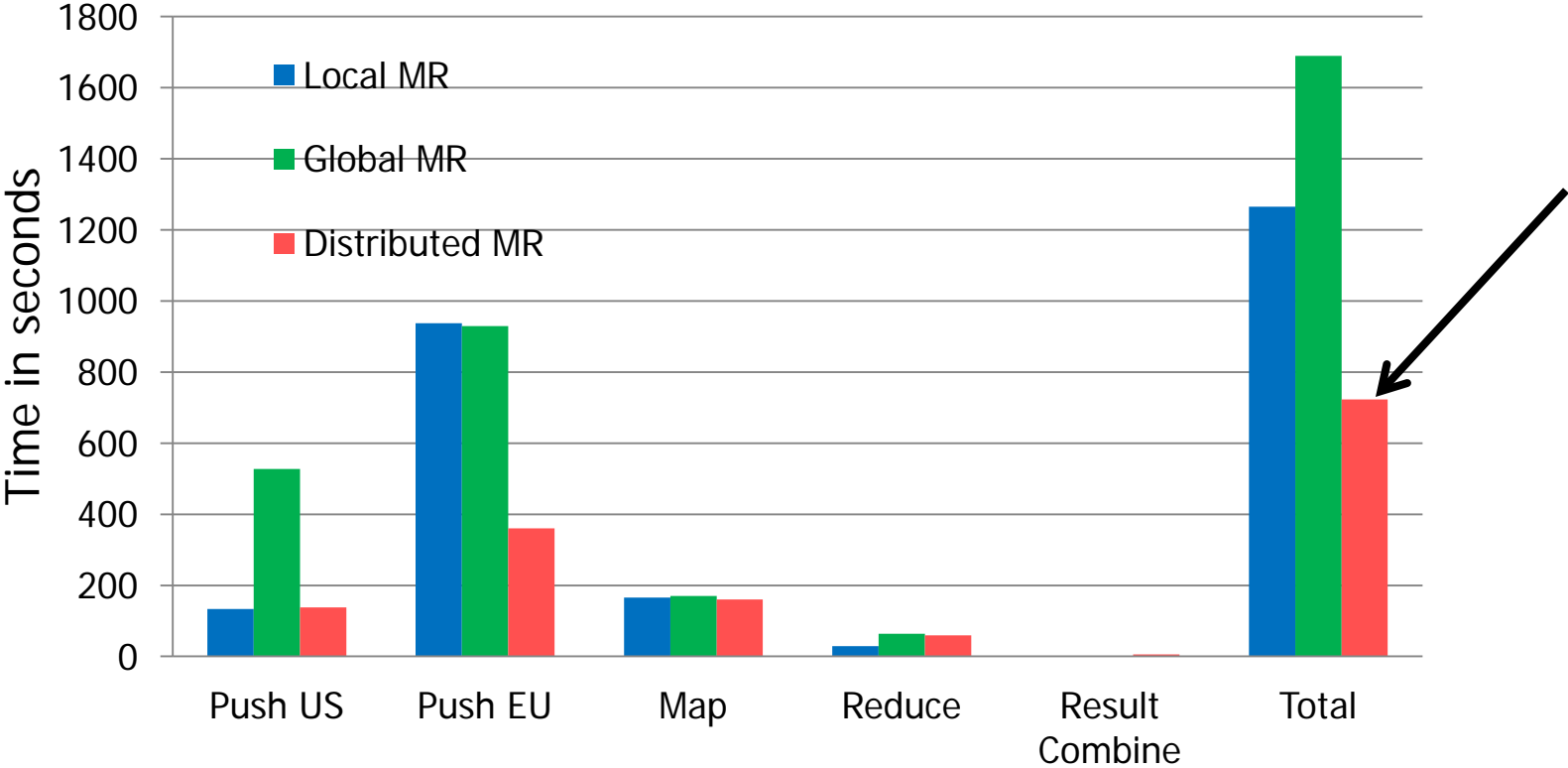
# Option 1: Local MapReduce



MapReduce Job → Final Result

Data Push (Fast)

Data Source (US)

Data Center (US)

Data Center (EU)

Data Source (EU)

Data Push (Slow)

# Option 2: Global MapReduce

MapReduce Job

Final Result

Data Push (Fast)

Data Push (Fast)

Data Center (US)

Data Center (EU)

Data Source (US)

Data Source (EU)

Data Push (Slow)

Data Push (Slow)

# Option 3: Distributed MapReduce



Combine Results

Final Result

MapReduce Job

MapReduce Job

Data Push (Fast)

Data Push (Fast)

Data Center (US)

Data Center (EU)

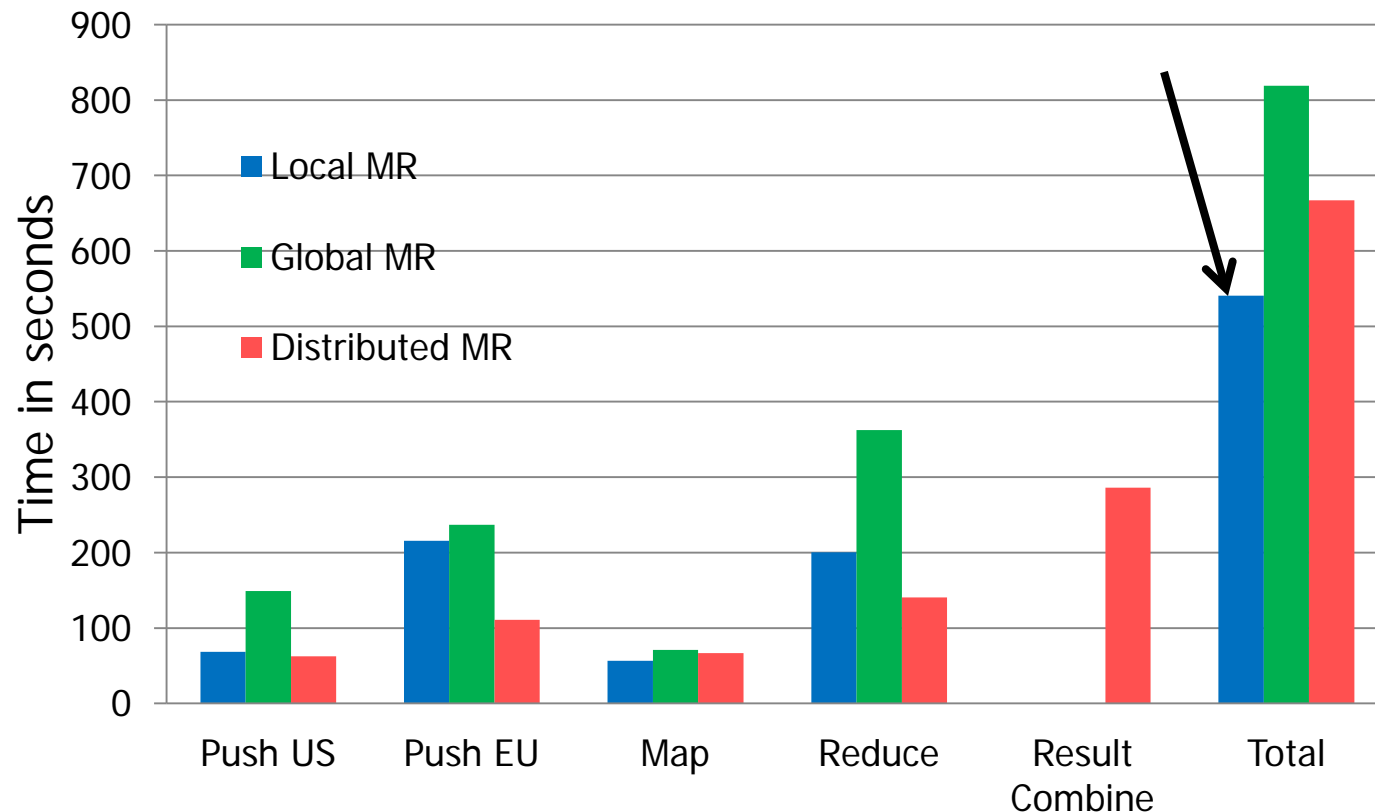Data Source (US)

Data Source (EU)

# PlanetLab: WordCount (text data)
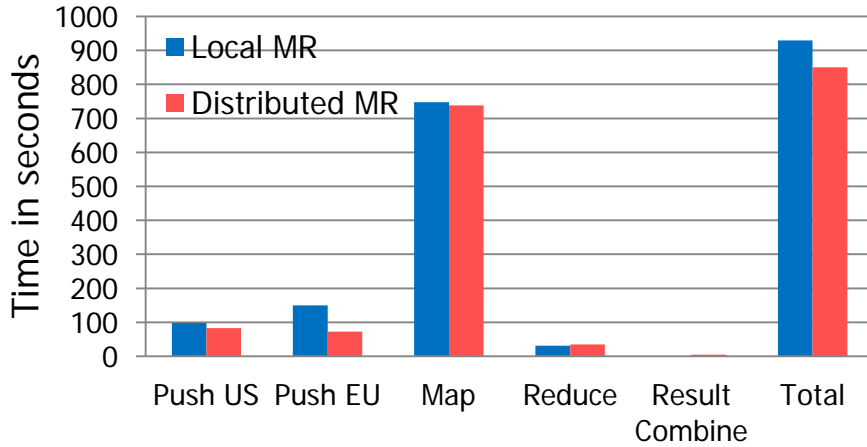


- Distributed MR works best in presence of data aggregation

# PlanetLab: WordCount (random data)



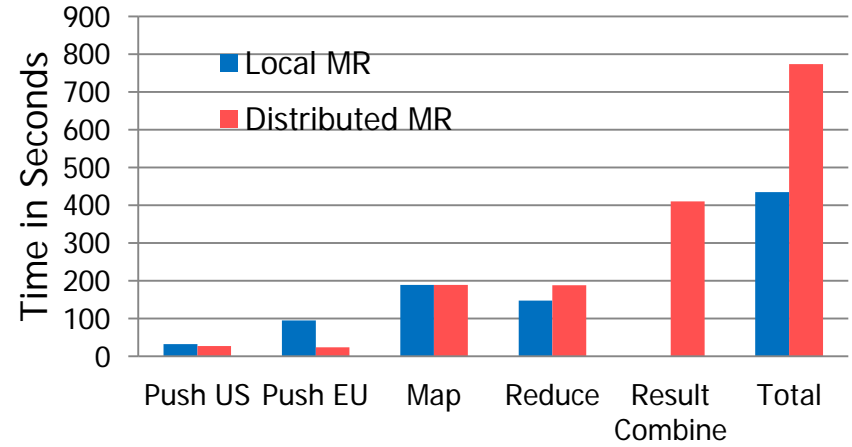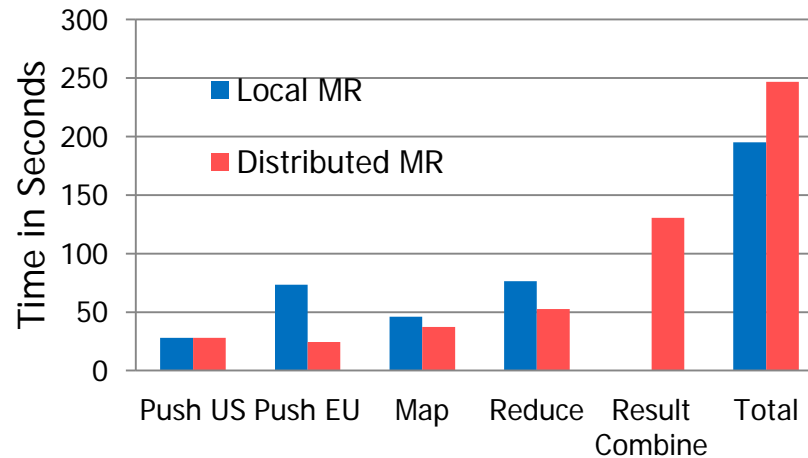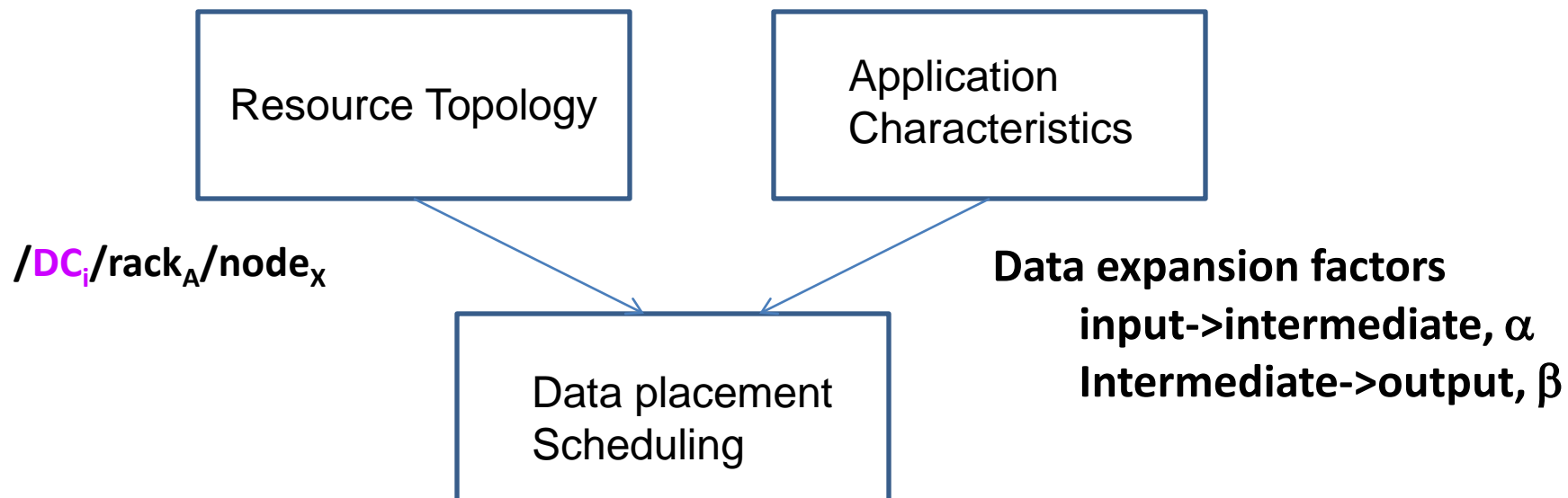- Local MR works best in presence of data ballooning

# EC-2 Results

# Intelligent Data Placement for Global Services

- HDFS push
  - local node, same rack, random rack



Resource Topology

Application Characteristics

/**DC$_i$**/rack$_A$/node$_X$

Data placement Scheduling

**Data expansion factors**
**input->intermediate, $\alpha$**
**Intermediate->output, $\beta$**

# Experimental Results (Word count)
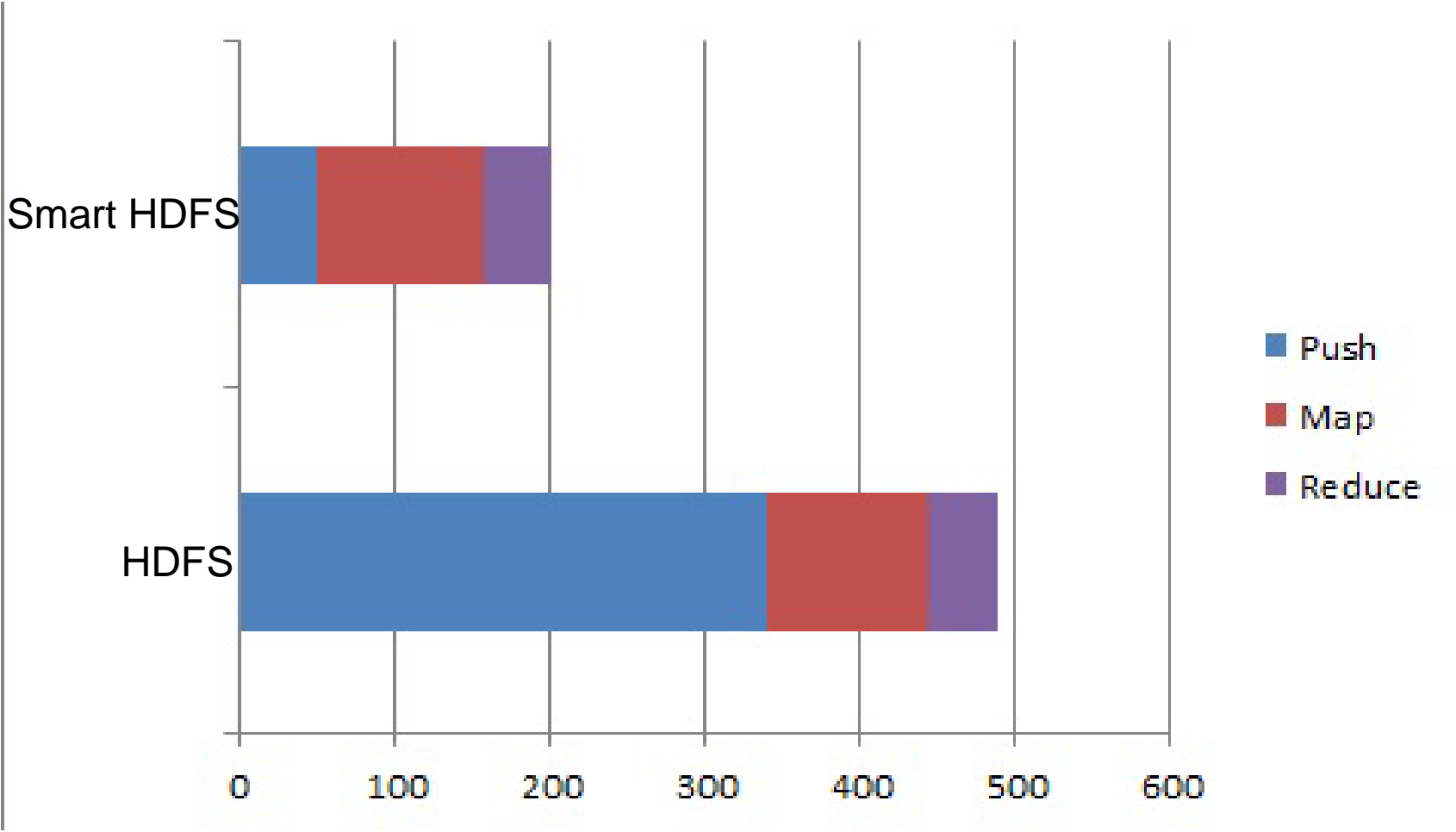
# Summary

- Cloud Evolution
  - mobile users, big data, privacy/trust, global services

- Our Vision of the Cloud
  - locality of users, data, other clouds/data centers, user-centric behavior