Jon Weissman and Abhishek Chandra
(+ great UMn students)

Department of CS&E
University of Minnesota

Key Trends

- Client technology
  - devices: smart phones, ipods, tablets, sensors
- Big data
  - located at the network edge
- Privacy/trust
  - local clouds
- Multiple DCs/clouds
  - global services

Minnesota Cloud Research

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

Project Clusters

- Power at the edge
  - big data, locality
- Cloud-2-Cloud
  - multiple clouds/DCs
- Mobile user
  - user-centric cloud

Nebula

DMapReduce

Mobile cloud

Big Data Trend

- Big data is distributed
  - earth science: weather data, seismic data
  - life science: GenBank, NCI BLAST, PubMed
  - health science: GoogleEarth + CDC pandemic data
  - web 2.0: user multimedia blogs
  - “everyone is a sensor”
- Cost in moving data to the cloud

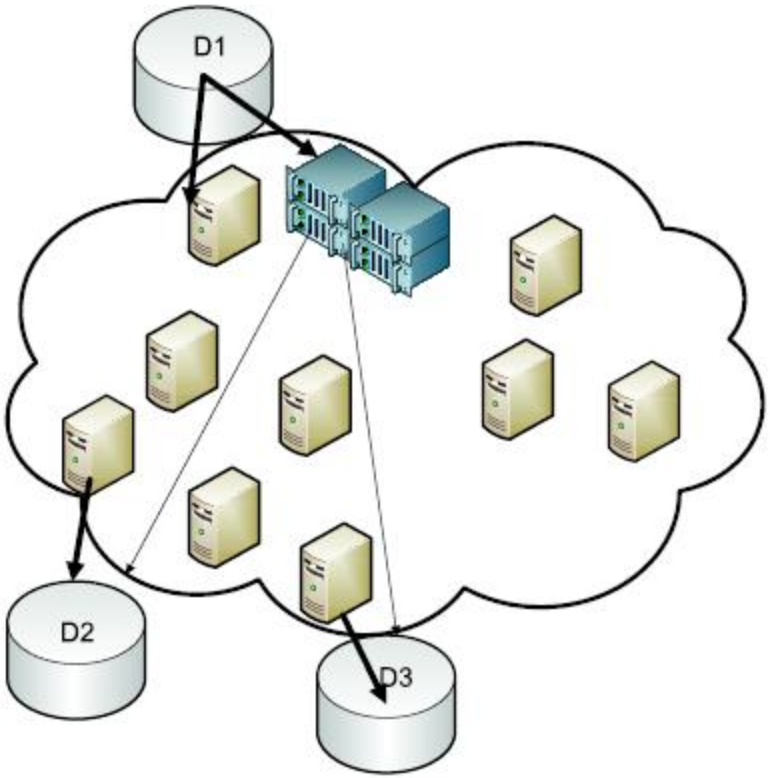
Big Data Trend: Nebulas

- Process data “close by”
  - fully and/or on-route to the central cloud
  - cost: save time and money
  - privacy (think: patient records)

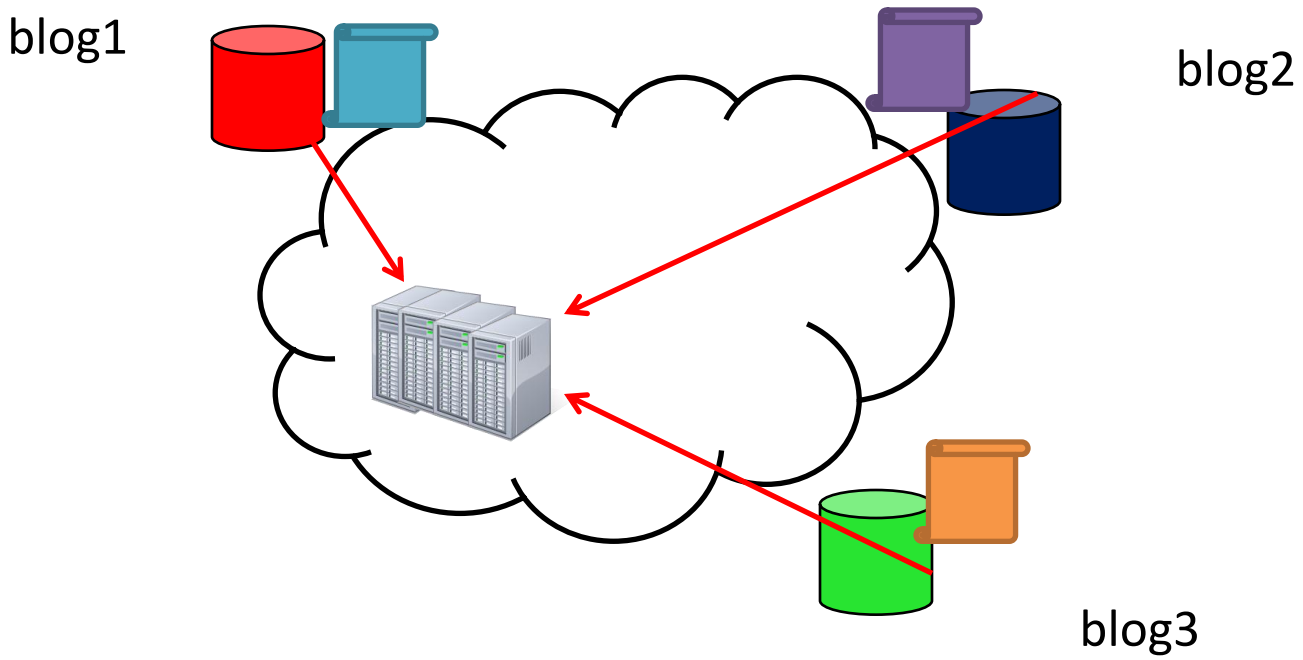
- Close by
  - network distance
  - trusted peers

Example: Dispersed-Data-Intensive Services

- Data is geographically distributed
  - Costly, inefficient to move to central location

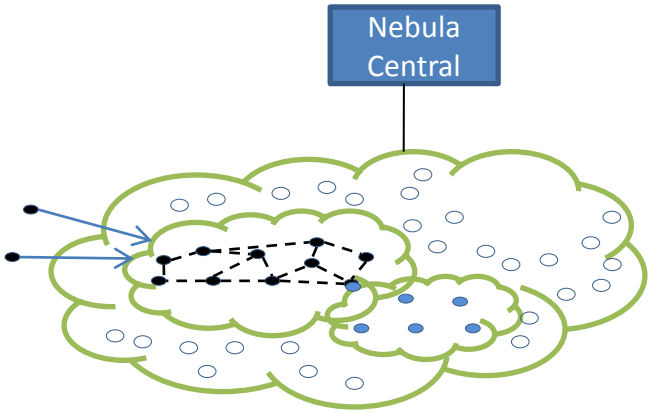


Example Instance: Blog Analysis



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



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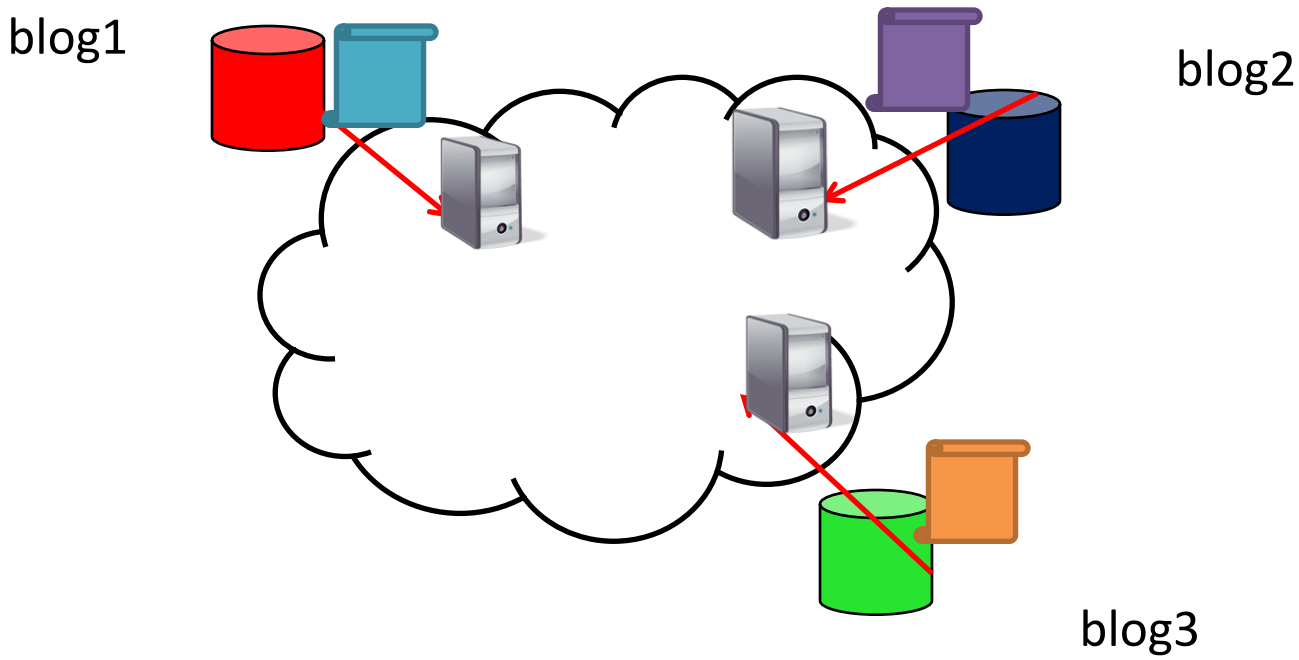
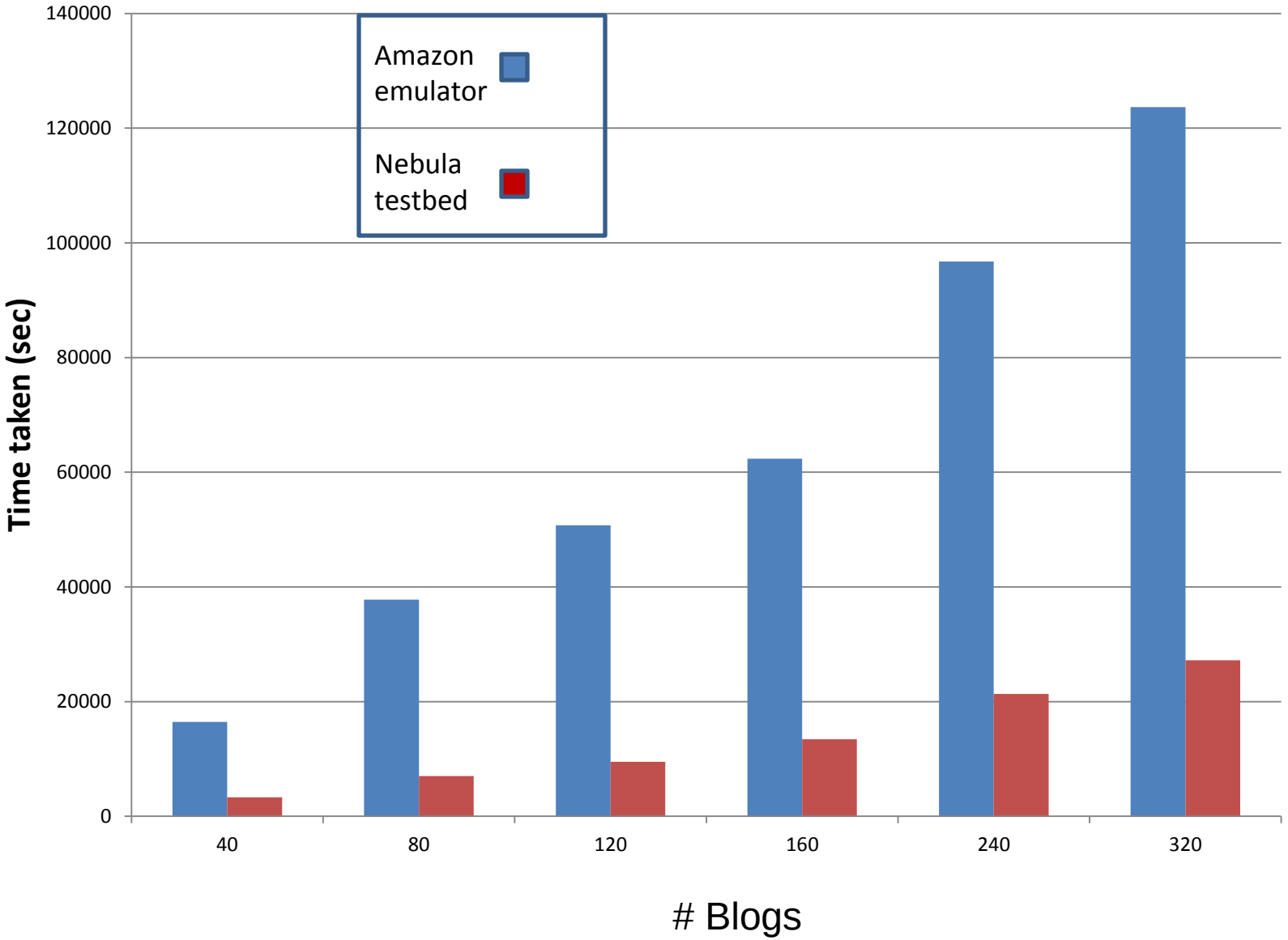


Blog Results



Current Status

- Prototype running on PlanetLab
- Distributed Data-Store Service
- Network Dashboard Service
- Node software stack
  - native client

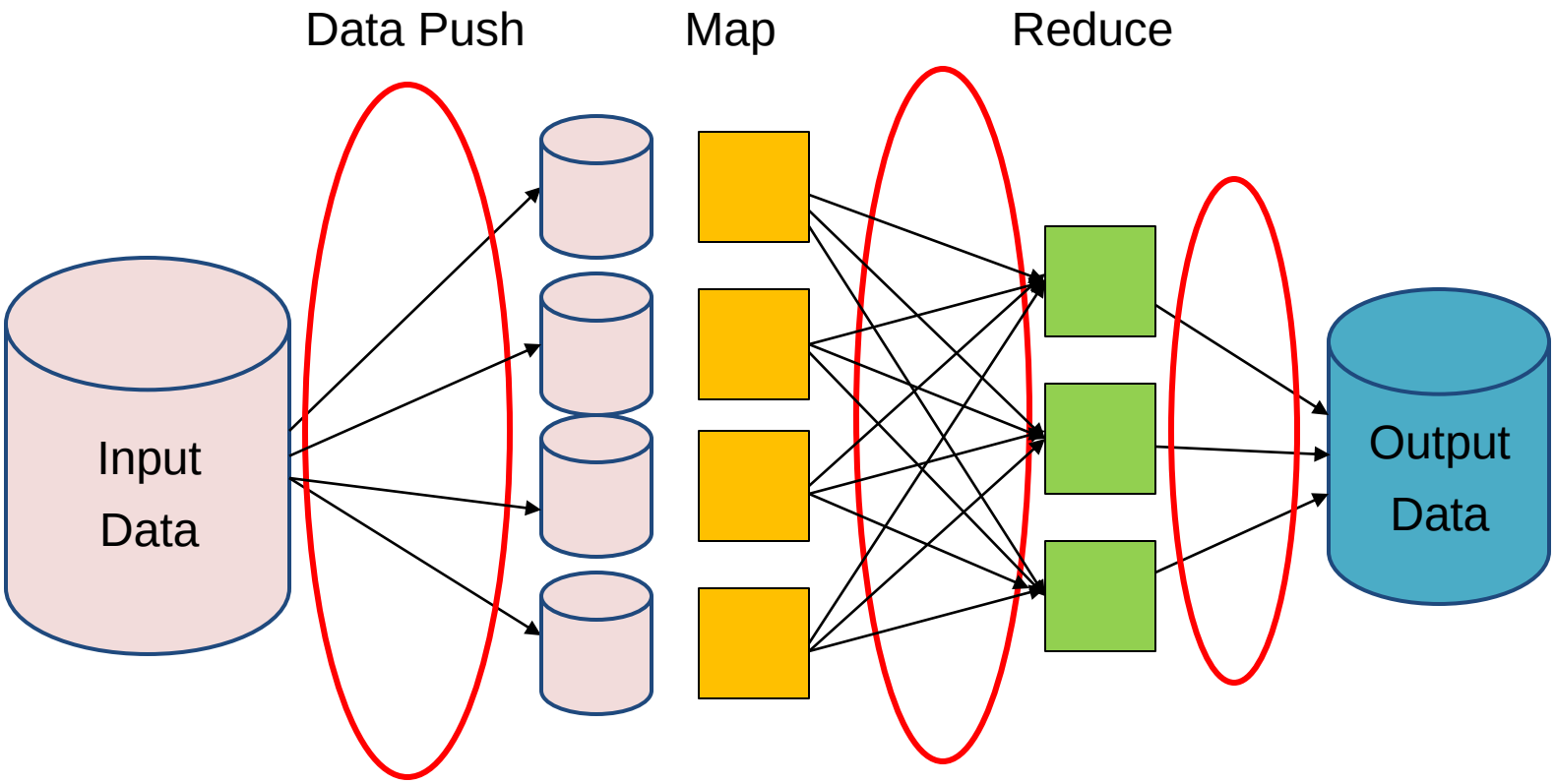
Nebula Going Forward

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

- Nebula + commercial cloud

  “use the edge opportunistically”

Big Data Trend: DMapReduce



Big Data Trend: Distribution

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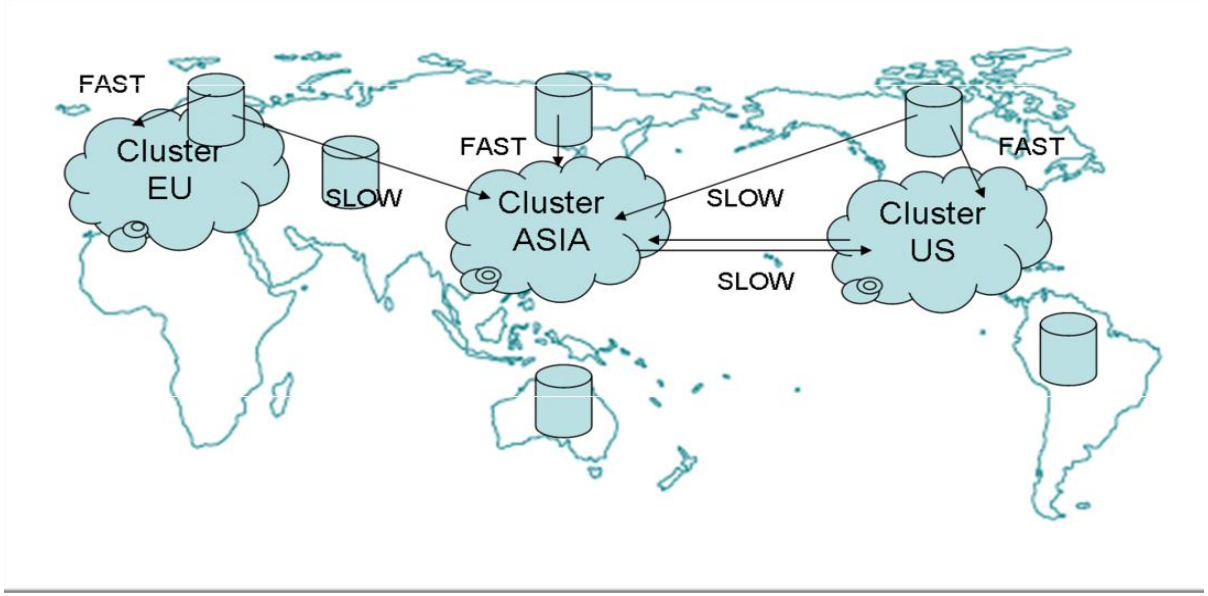
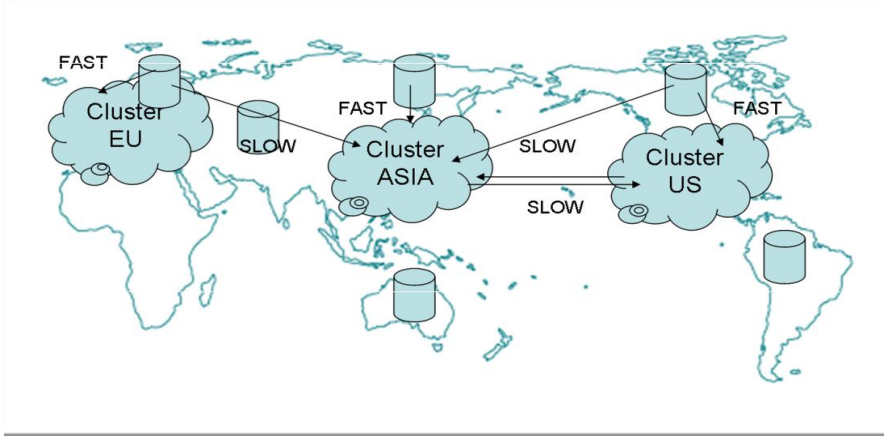
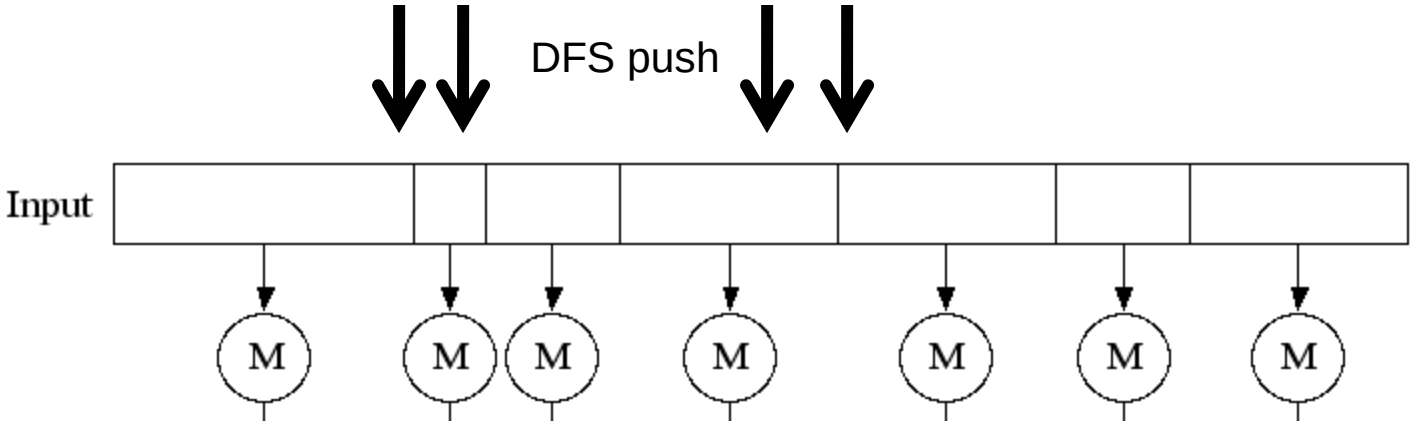


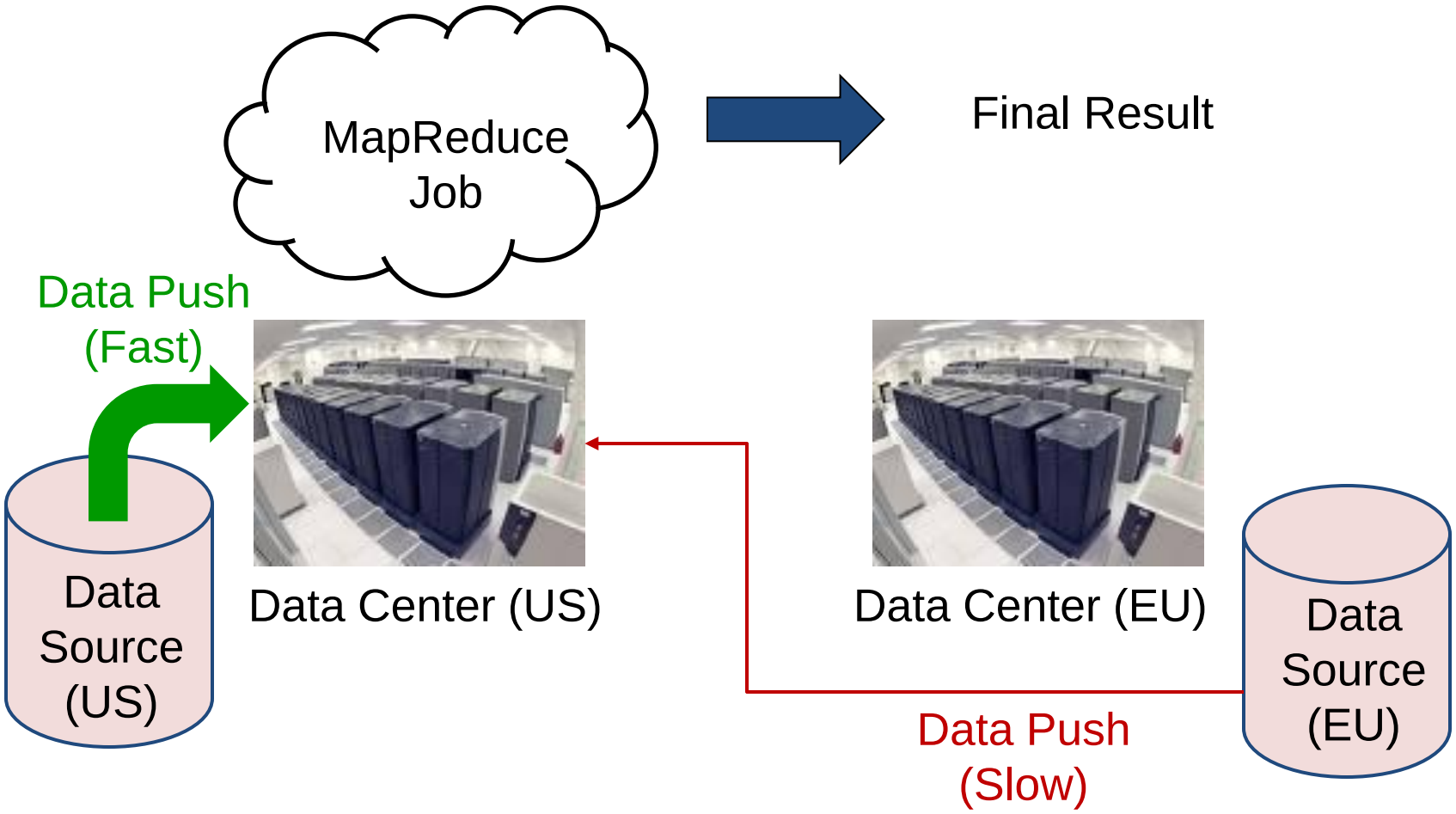
Wide-Area MapReduce



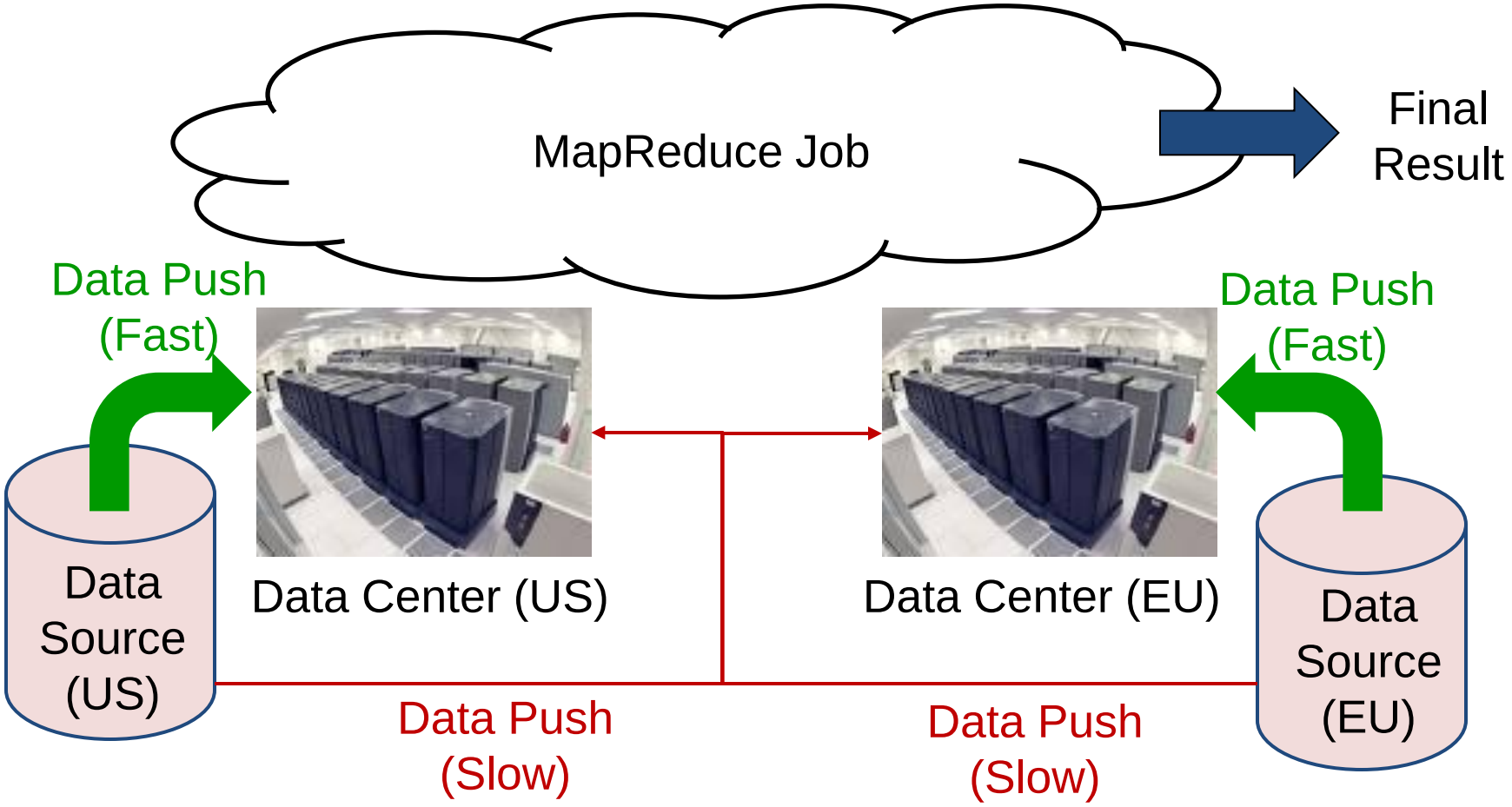
- Data in different data-centers
- Run MapReduce across them
- Data-flow spanning wide-area networks



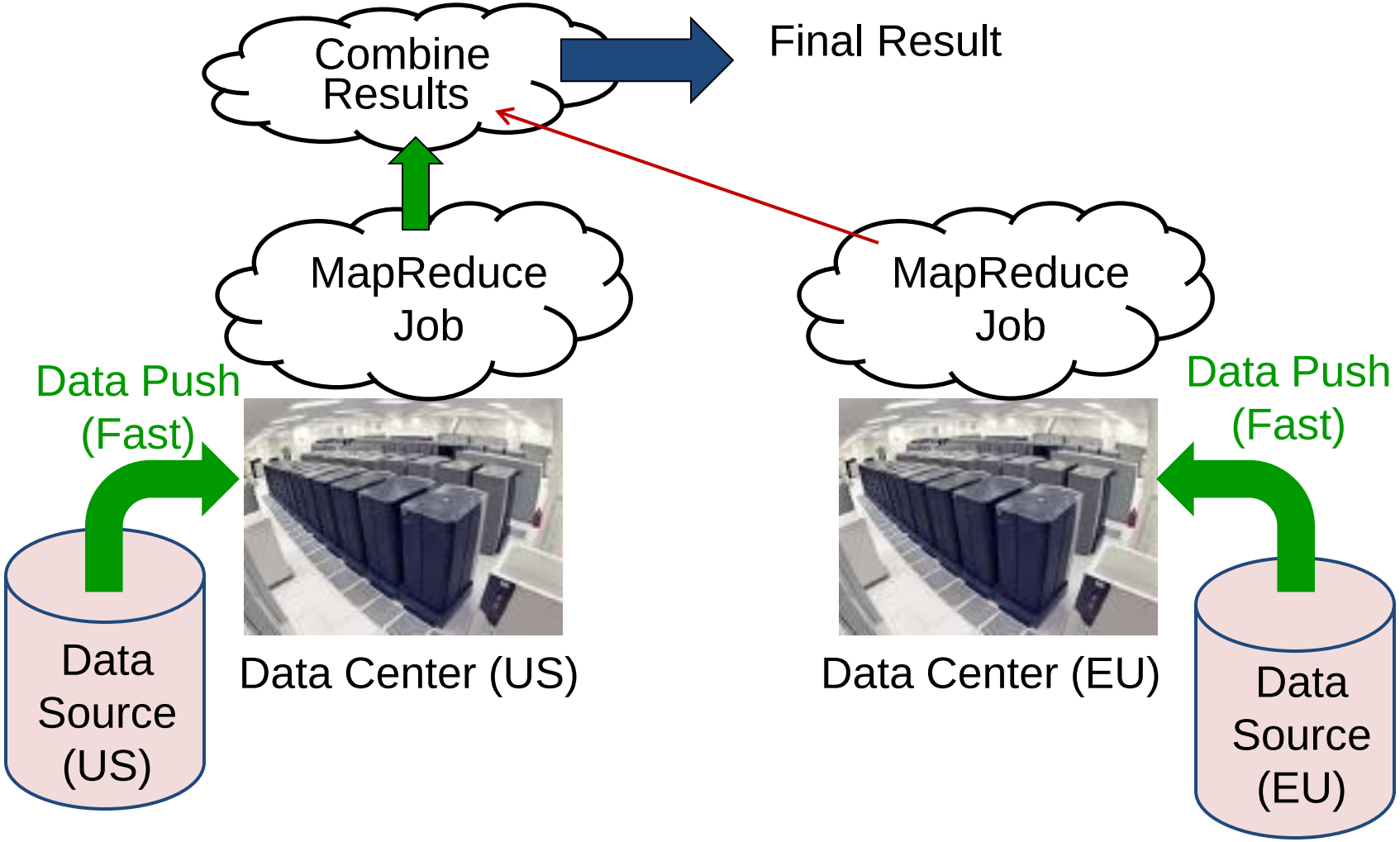
Option 1: Local MapReduce



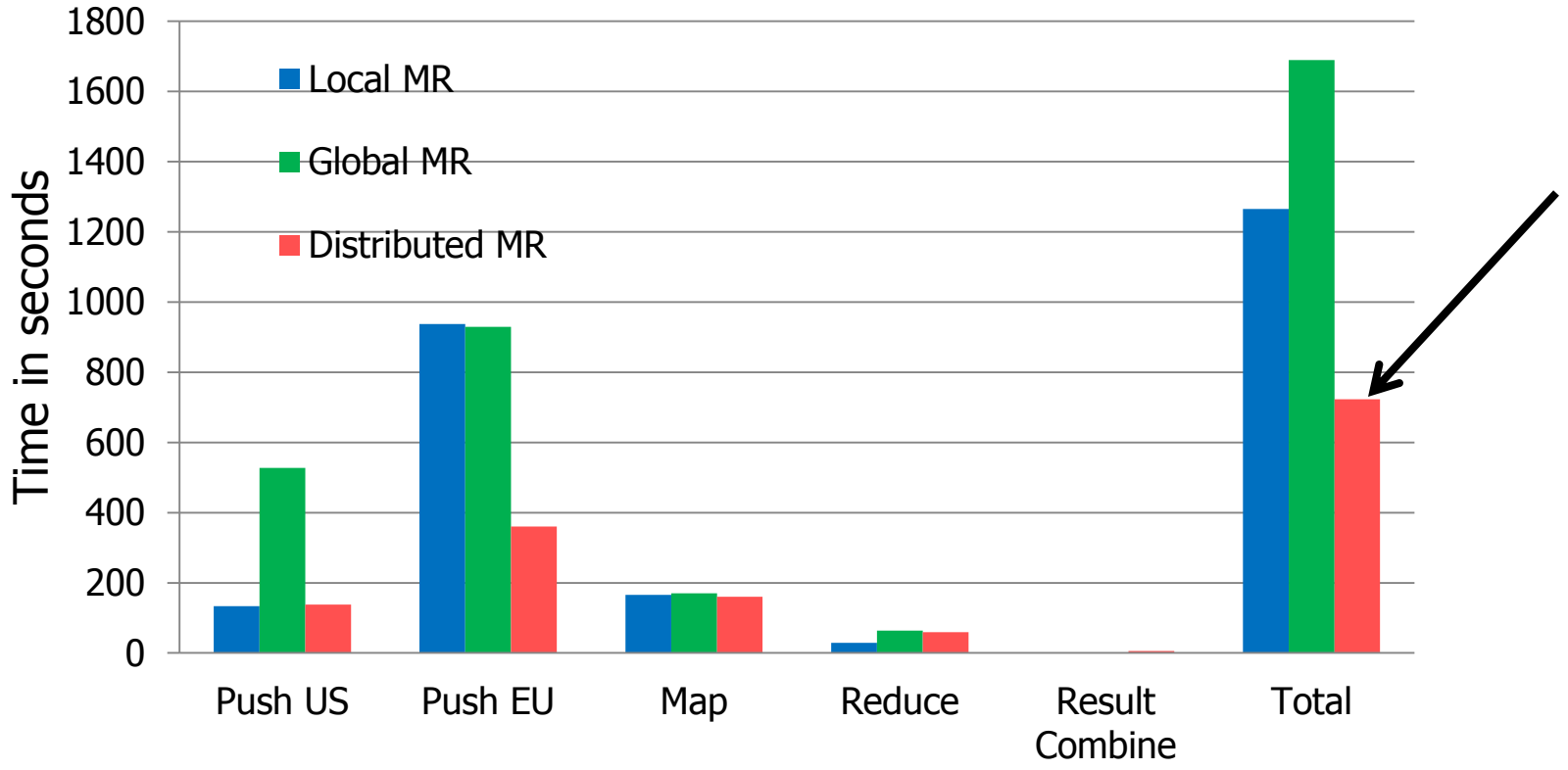
Option 2: Global MapReduce



Option 3: Distributed MapReduce

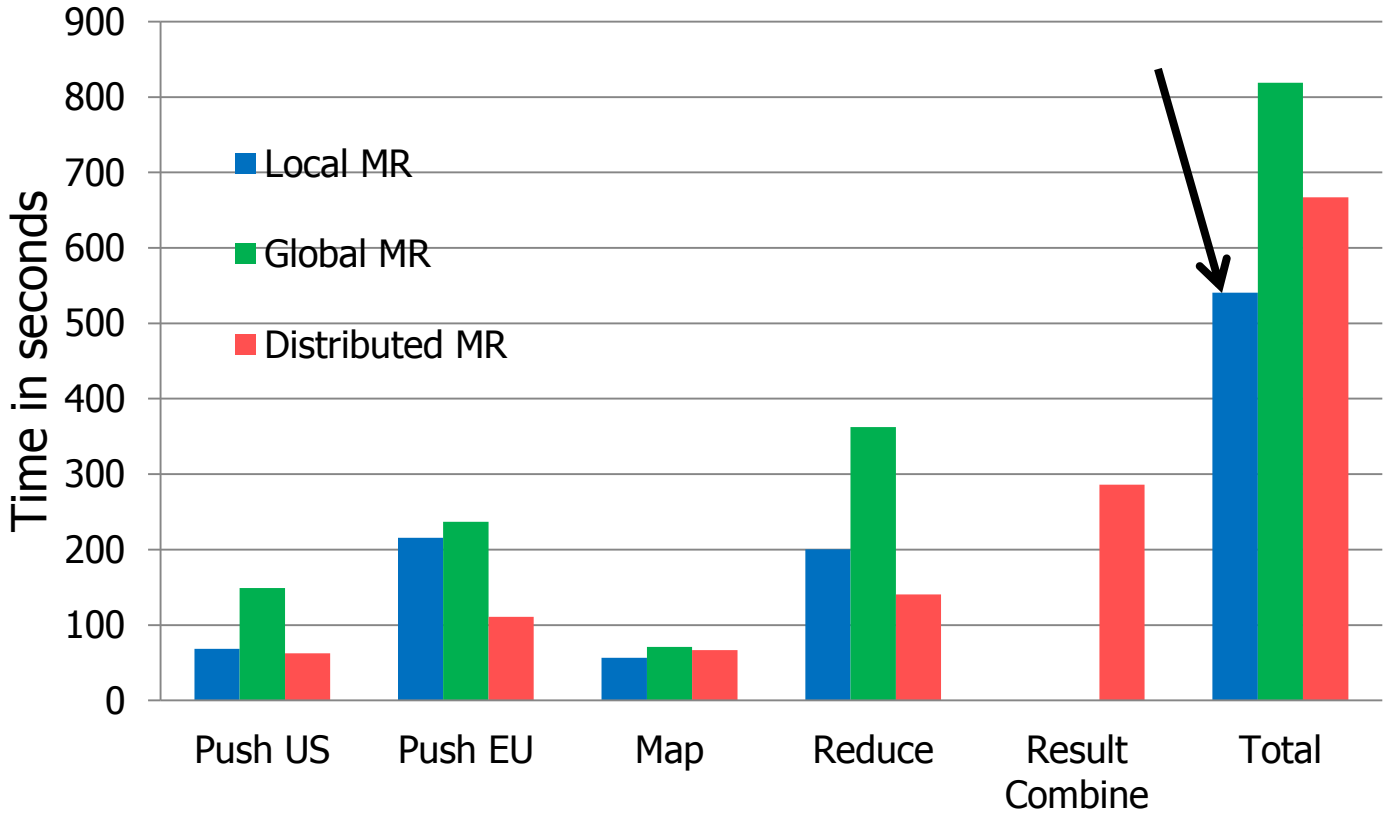


PlanetLab: WordCount (text data)



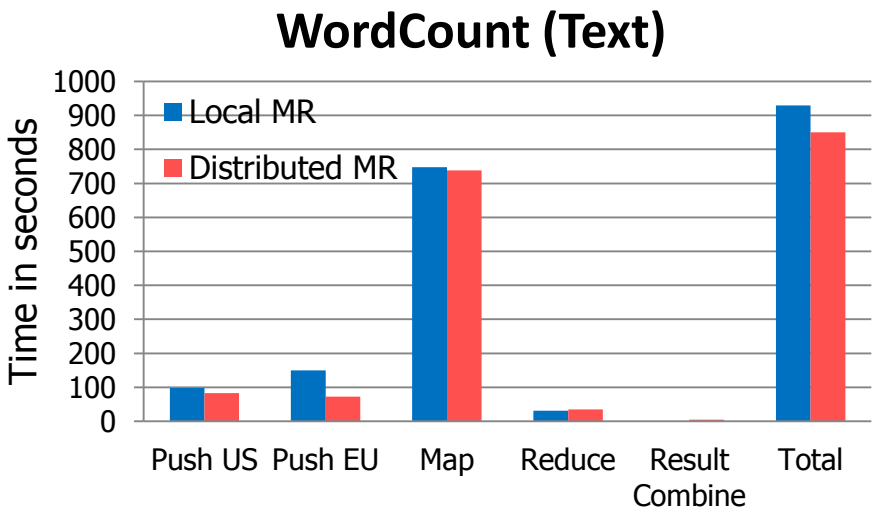
- Distributed MR works best in presence of data aggregation

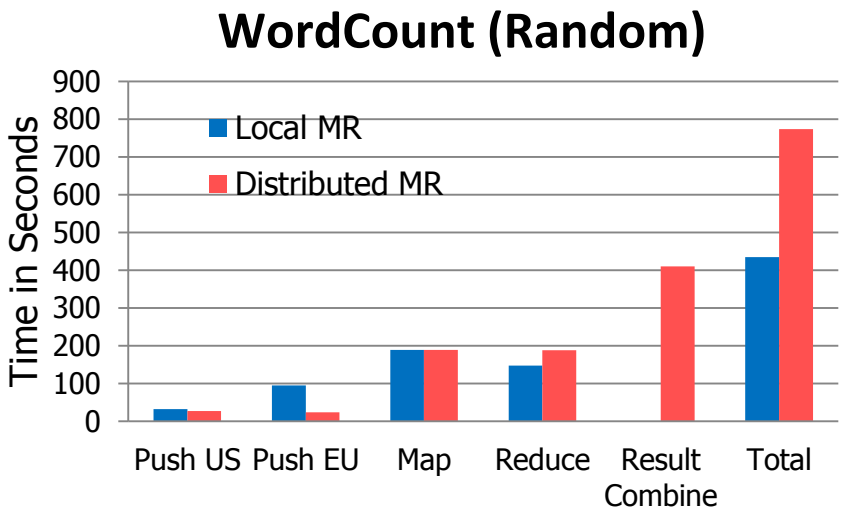
PlanetLab: WordCount (random data)

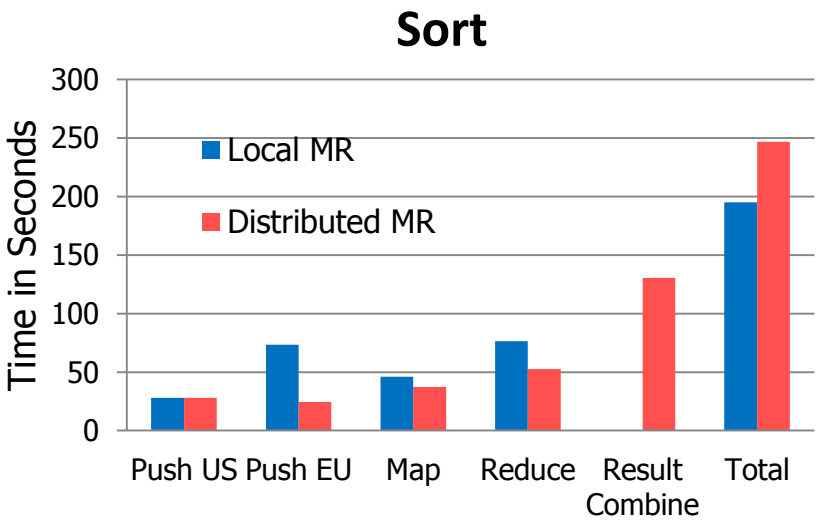


- Local MR works best in presence of data ballooning

EC-2 Results

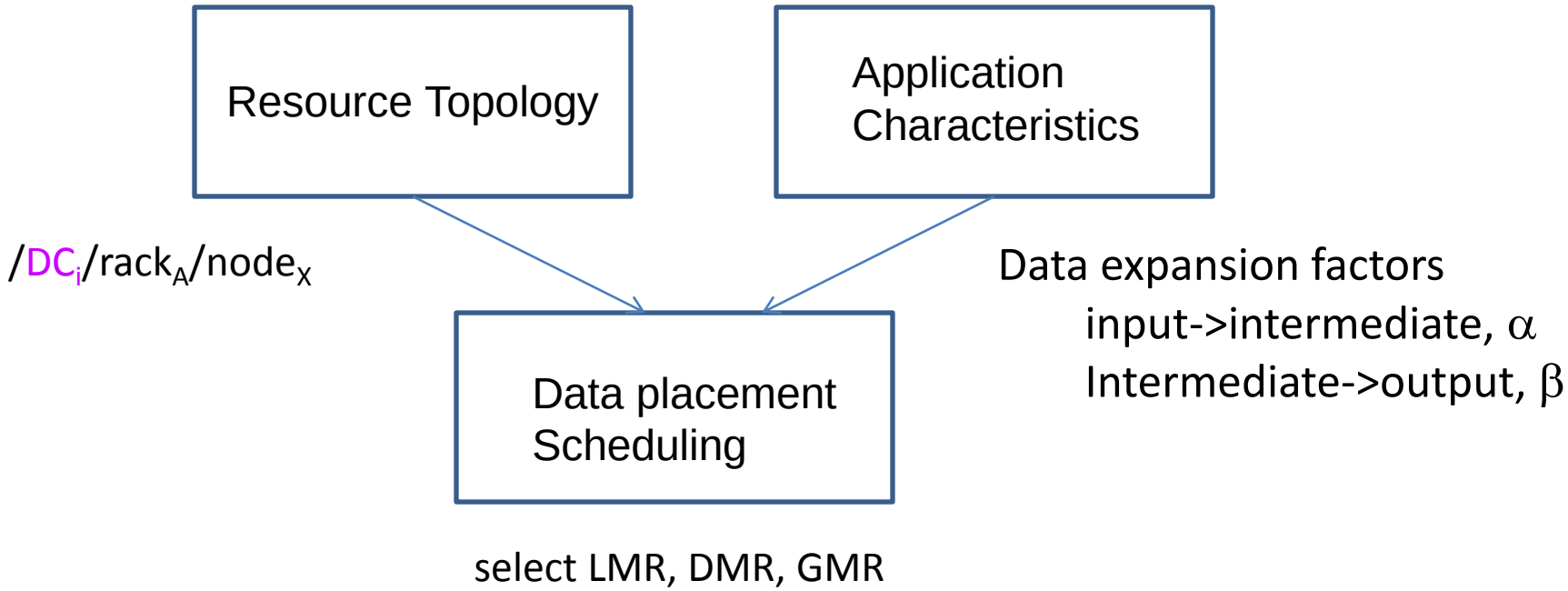

WordCount (Text)
Time in seconds
1000
900
800
700
600
500
400
300
200
100
0
Local MR
Distributed MR
Push US
Push EU
Map
Reduce
Result Combine
Total


WordCount (Random)
Time in Seconds
900
800
700
600
500
400
300
200
100
0
Local MR
Distributed MR
Push US
Push EU
Map
Reduce
Result Combine
Total


Sort
Time in Seconds
300
250
200
150
100
50
0
Local MR
Distributed MR
Push US
Push EU
Map
Reduce
Result Combine
Total

Intelligent Data Placement

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



Generalize beyond HDFS/MapReduce!

Mobility Trend: Mobile Cloud

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

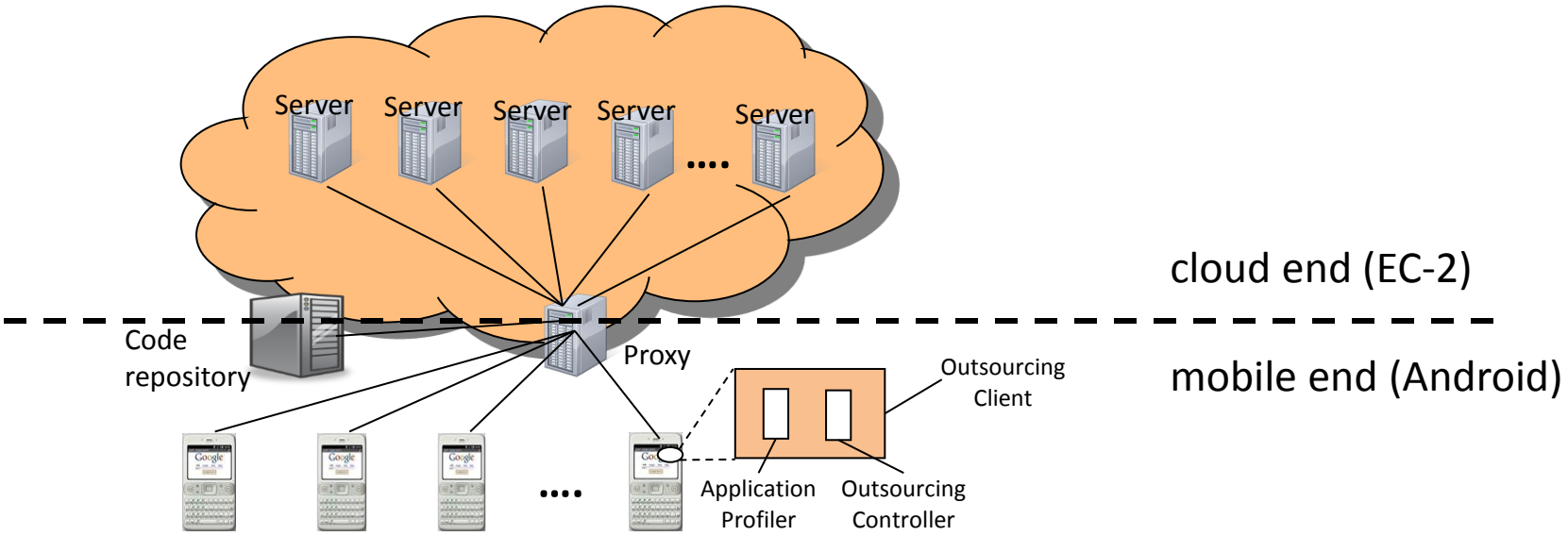
- Improve mobile user experience
  - performance, reliability, fidelity
  - tap into the cloud **dynamically** based on current resource state, preferences, interests, privacy

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

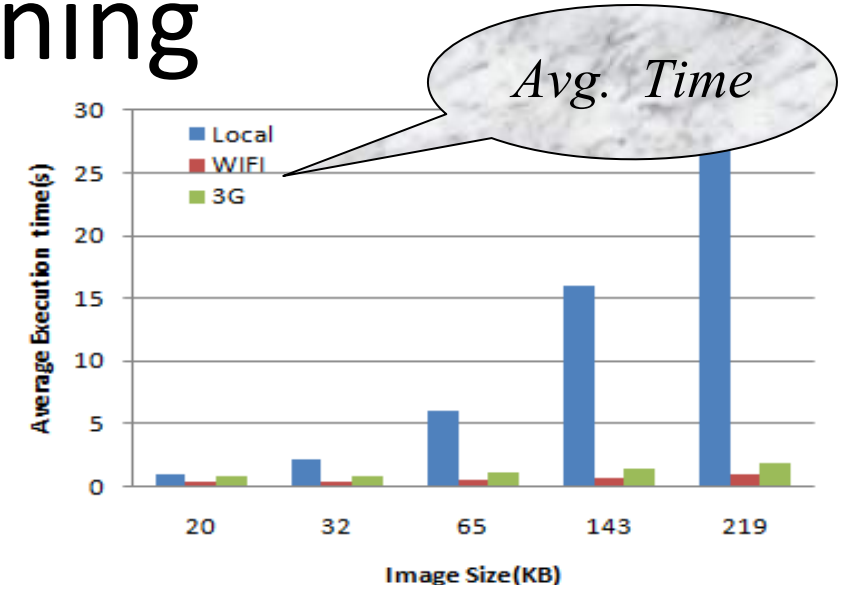
Outsourcing

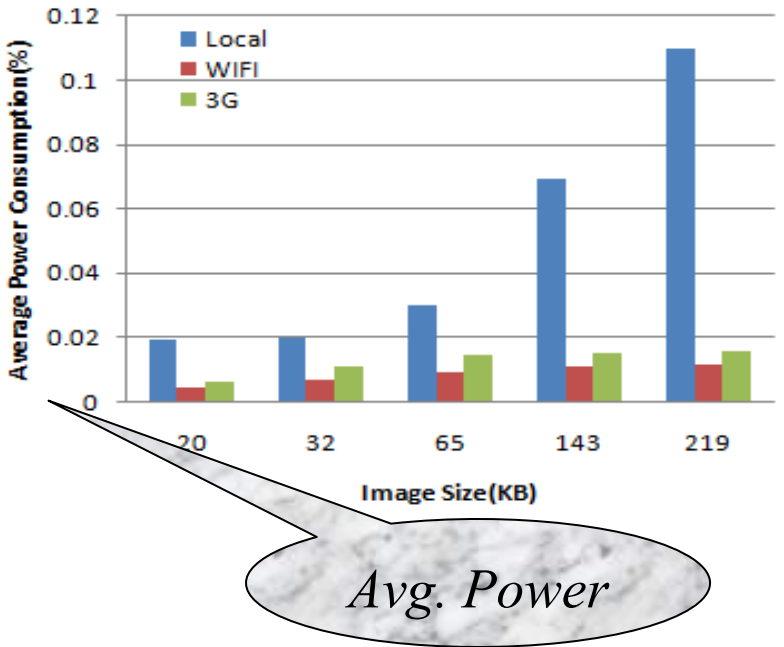
- Partitioning across (Mobile <->Server <-> Cloud)
  - local data capture + cloud processing
  - images/video, speech, digital design, aug. reality



Experimental Results -Image Sharpening

- Response time
  - both WIFI & 3G
  - up to 27× speedup
  - 219K, WIFI
- Power consumption
  - save up to 9× times
  - 219K, WIFI

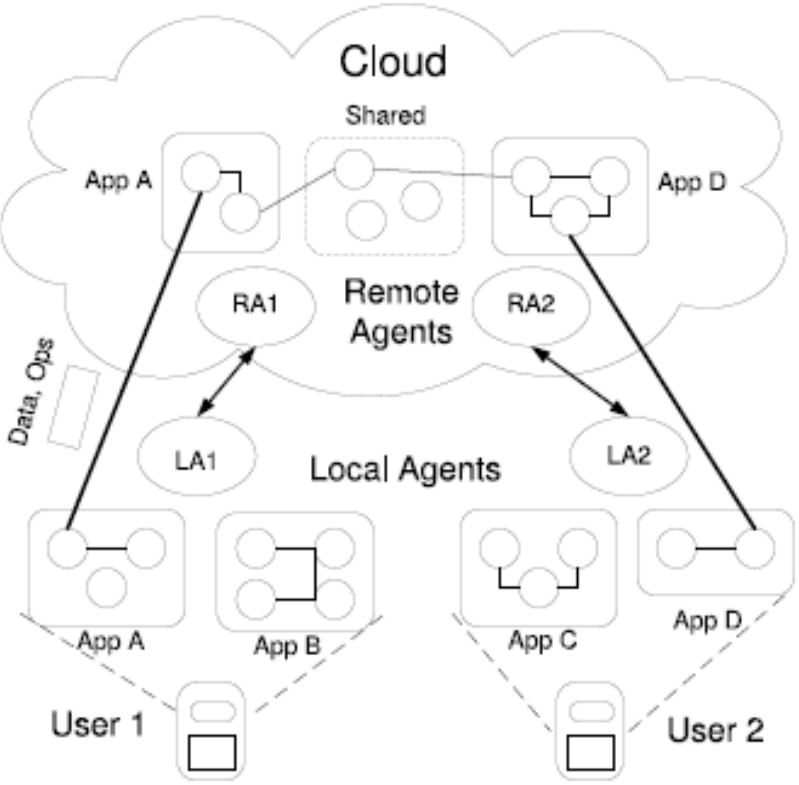




Cloud Speculation

- Dynamic user *profile*
  - contains *activities* in time and space
  - "read nytimes.com bet. 9-9:30am on the train; likes technology articles"
  - associate with *context*
- Patterns are relationships between activities
  - repetitive, sequential, concurrent, time-bounded
  - "user always does X and then does Y"
- Exploiting patterns: pre-fetching, pre-computing, caching in the cloud

Smart cloud



Back-end speculation and optimization

Summary

- Cloud Evolution
  - mobile users, big data, privacy/trust, global
- Our vision of the Cloud
  - locality of users, data, other clouds/data centers, user-centric behavior