

Cloud Centric Service and Network Reliability

A New Perspective

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Overview

Conventional (Telco-centric) Approaches:

- Focus on communications only, no computing
- Build a network with enough redundant resources
- *Survivable routing* for a pair of end-nodes to protect against some switch/router and/or link failures

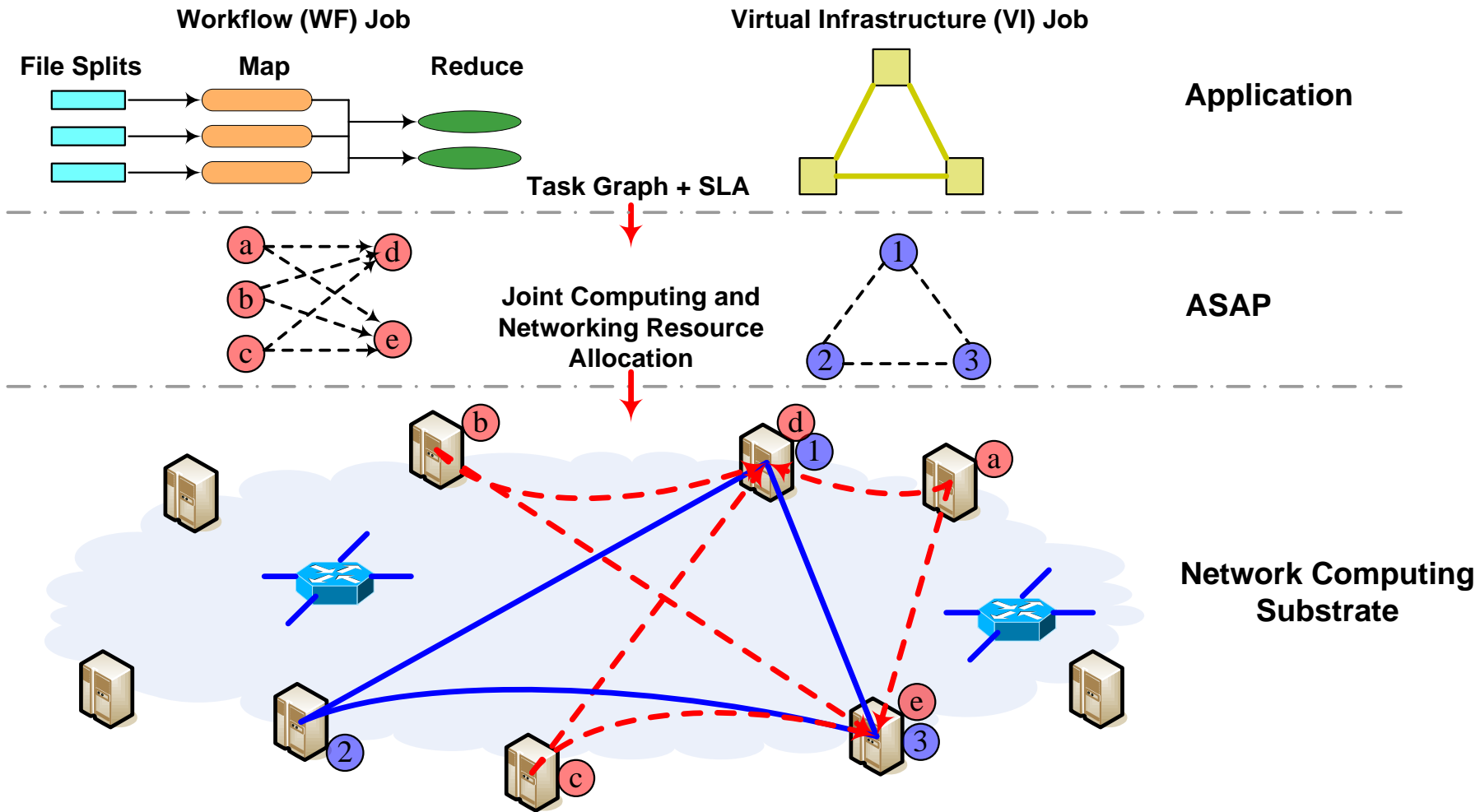
New (Cloud-centric) Approaches

- Consider both computing and communications
- Protect against failures of the *end-nodes* (e.g., datacenters)
- New approaches based on *application* requirements and migration technologies

Enable Distributed and Cooperative Datacenters

- Federated Computing and Networking System (**FCNS**): incorporates a larger scale **computing** and **networking** resources
- Distributed **Applications**
 - *Virtual Infrastructure (VI)*
 - a set of computing resources and connectivity (topology, bandwidth, delay bound)
 - *Workflow (WF)*
 - data-intensive computing tasks or
 - Service functional chaining (SFC) in the context of NFV
 - Directed acyclic graph (DAG) where directed edges imply precedence among the tasks

Cloud-centric View of FCNS and Applications



Application Specific and Agile Private (ASAP) A Service Platform for NFV

- Resources to be Allocated
 - The set of computing clusters assigned for the job
 - The physical connections established among the chosen computing clusters for the job
- Desired Features
 - On-demand allocation and service scheduling
 - Survive large-scale failures (e.g., cluster failures)
- Require New Resource Management Solutions
 - *Jointly optimize* computing and communications

Motivation for New Thinking

Main challenges and limitations in current approaches:

- 1) While effective for dealing with limited or small scale failures, they are not applicable to a cluster-wide failure
- 2) survivable routing is meaningful only if the end points involved are not affected by the failures.

Proposed Survivable VI Mapping (*SURVIM*) Approach

- a) Users/Applications' point of view: It is both sufficient & necessary to ensure that the *applications can keep running* after failures
- b) Migration techniques: many tasks/jobs can be *migrated* and continue to run at the survived facilities/locations

Survivable Virtual Infrastructure Mapping (SURVIM)

Basic Idea:

- Input :
 1. A Virtual Infrastructure (VI) or WF representing an application's requirements on computing and communications resources
 2. A given FCNS substrate consisting of computing clusters and communication networks
 3. Desired survivability requirements and expected failures to be protected
- Output: a survivable mapping from the VI to the substrate
 - Even if an cluster fails, the application can still be run after the task/VM migration to a backup cluster
 - The migrated task can still communicate with the other tasks of the same application, so the **VI remains intact**.

A Simple VI Mapping Problem

- **Given:**

- A VI request :

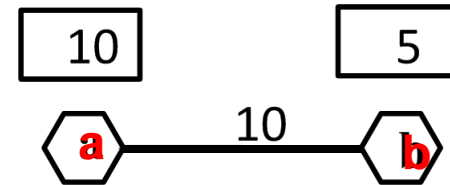
$$G_L=(V_L,E_L)$$

- The FCNS Substrate :

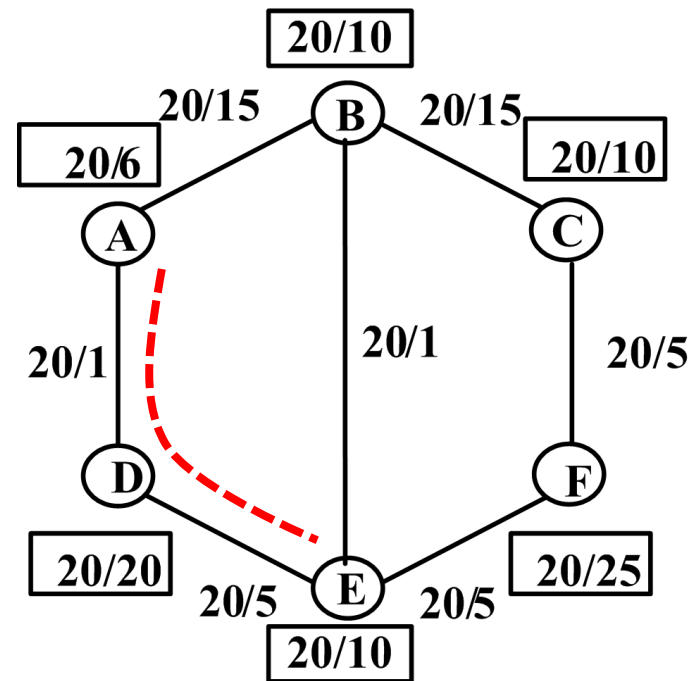
$$G_S=(V_S,E_S)=(V_F\cup V_X,E_S)$$

- **Task: find VI mapping**

- Map nodes (with Comp. resources)
 - 1-to-1 mapping from V_L to V_F
- Map links (with Comm. resources)
 - Each link in G_L to a path in G_S
- Objective: Min Comp+Comm costs
 - Nodes and links in FCNS have different capacities and unit costs



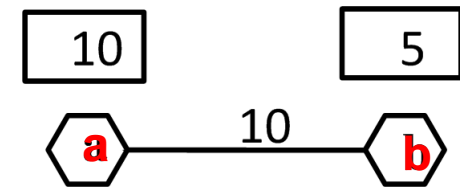
(a) VI Request



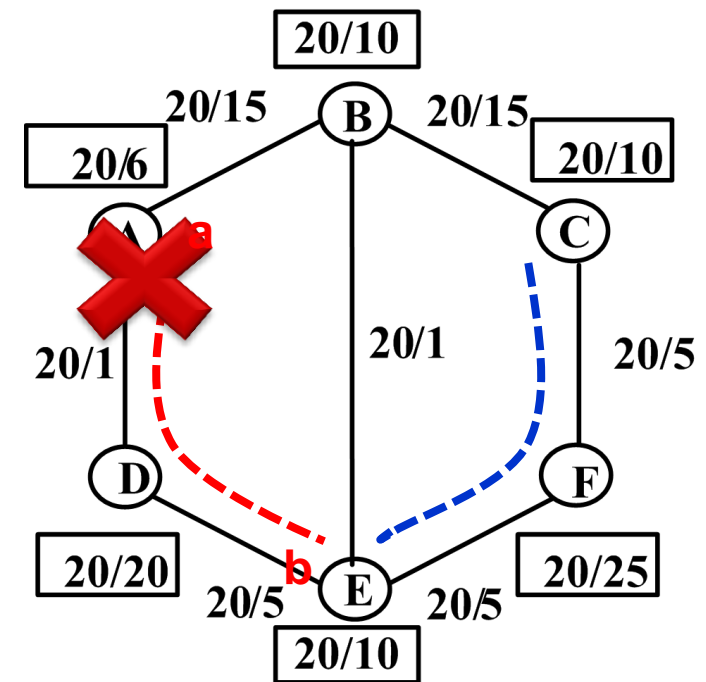
(b) FCNS Network

Reserve/Allocate Backup Resources

- Given:
 - A VI request $G_L=(V_L,E_L)$
 - The FCNS Substrate $G_S=(V_F \cup V_X, E_S)$
 - Critical failures R affecting clusters in G_S requiring non-local recovery
- Task: Find *survivable* VI mapping
 - For each failure $r \in R$
 - Find a backup cluster in G_S for each affected (primary) cluster
 - Find a backup path in G_S for each affected (primary) path
 - Perform migration after each failure
 - Objective: minimize the sum of the *primary* and *backup* costs

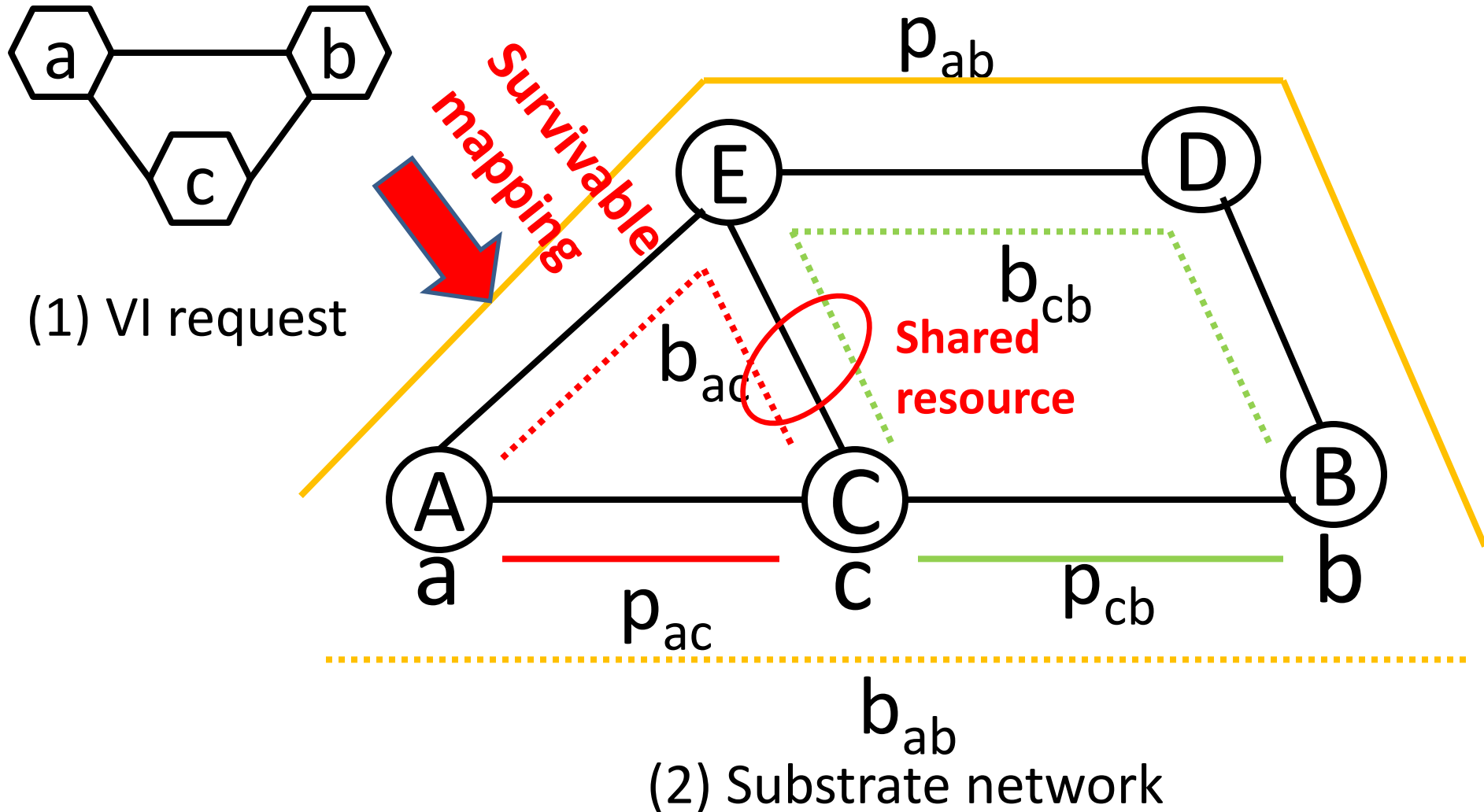


(a) VI Request

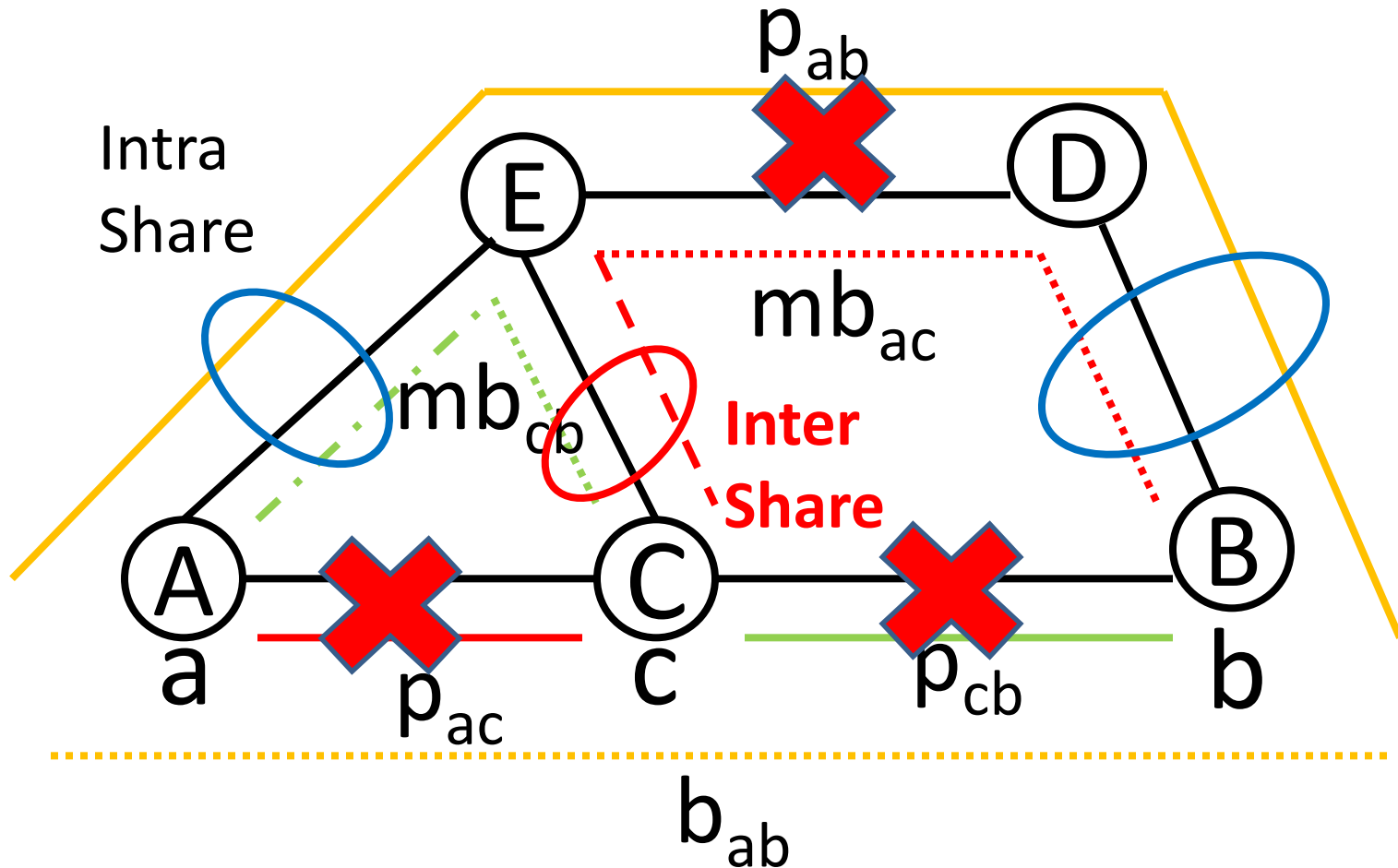


(b) FCNS Network

Traditional Shared-Path Protection Example



Migratory Shared-Protection in SURVIM



SURVIM Approaches/Algorithms

One step: map a VI directly to the FCNS substrate a

- Survivability is considered when mapping the VI by finding backup clusters/paths in FCNS [Liu&Qiao OFC09], [Yu&Qiao OFC09], [Yu & Qiao IC3N10, GC10, OFC11, ICC11]

Two steps: 1) enhance a VI to *EVI with sufficient redundancy*; 2) map EVI to FCNS substrate

- Consider survivability and need for redundancy earlier in 1), not in 2) [Qiao et al. OFC'11]

Concluding Remarks

Joint Computing and Communications Resources Allocation

- Federated Computing and Network System (*FCNS*) substrate
- Application-Specific, Agile & Private (*ASAP*) platform for NFV
- New cloud-centric perspective on survivability based on task/VM migration (backup both *clusters* and *paths*)

Efficient Survivable VI Mapping (SURVIM) algorithms

Ongoing Work: Progressive (Multi-stage) Network Recovery Strategy (for Failures in *Interdependent Infrastructures*):

- Given *limited repair resources*: materials, man-power, logistics..
- Optimize the repair/recovery sequence or order for each part
- Objective: maximize certain time-sensitive application performance or user experience.

Thank You

Questions and Comments?

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