A Performance Evaluation Model for Effective Job Scheduling in Global Computing Systems

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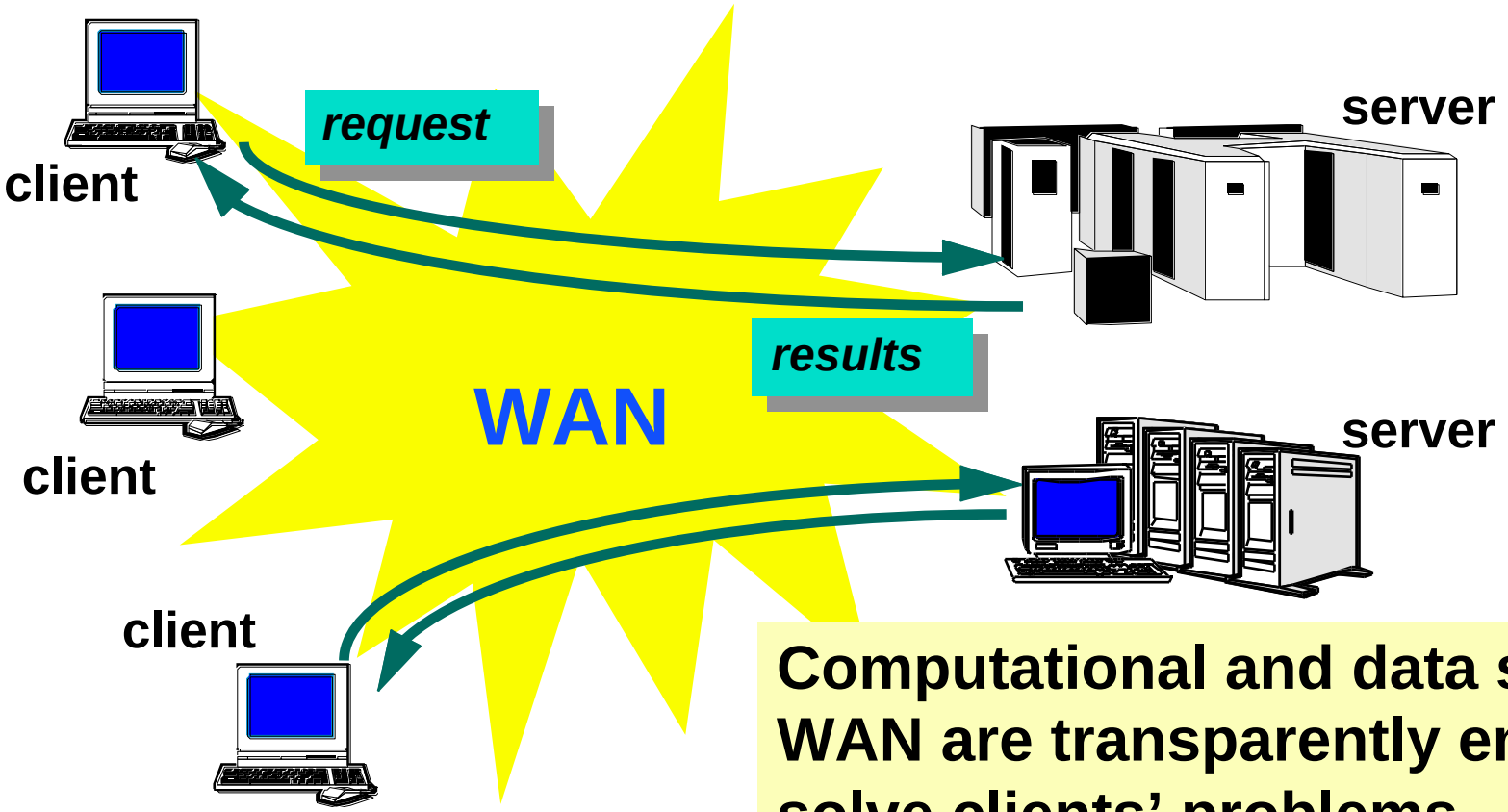
Global Computing System

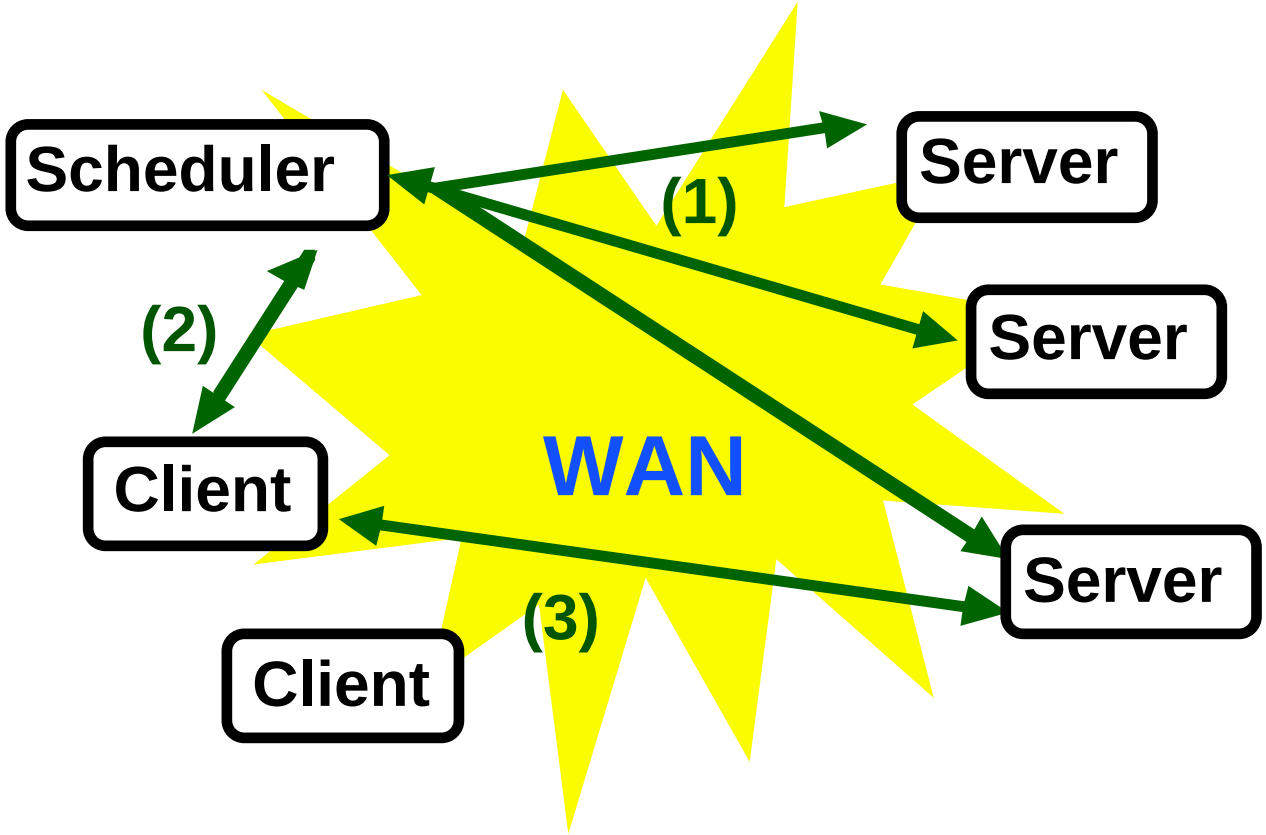


Computational and data servers in WAN are transparently employed to solve clients' problems.

Proposed Global Computing Systems:

- **Globus, Netsolve, Ninf, Legion, RCS, etc.**

Job Execution in Global Computing



(1) Scheduler collects load information.
(2) Client queries Scheduler about the suitable server.
(3) Client requests execution of the job, transmits data to the designated server, and receives results.

Job Scheduling for Global Computing

An effective job scheduling scheme is required to achieve high-performance global computing!

Software Systems for Job Scheduling

- **AppLes, Netsolve agent, Nimrod, Ninf metaserver, Prophet, etc.**

Scheduling Algorithm

- **Effective algorithm has not been proposed.**
- **The performance of algorithm has not been evaluated sufficiently.**

Performance Evaluation Model

Model for Locally Distributed System

- well studied
- embody only computational servers

Model for Global Computing System

- not established
- should embody both computational servers and networks between clients and servers

A performance evaluation model for job scheduling in global computing systems is required!

Proposed Performance Evaluation Model

Queueing Network

Global Computing System

- Q_s computational servers
- Q_{ns} network from the client to the server
- Q_{nr} network from the server to the client

Congestion on Servers and Networks

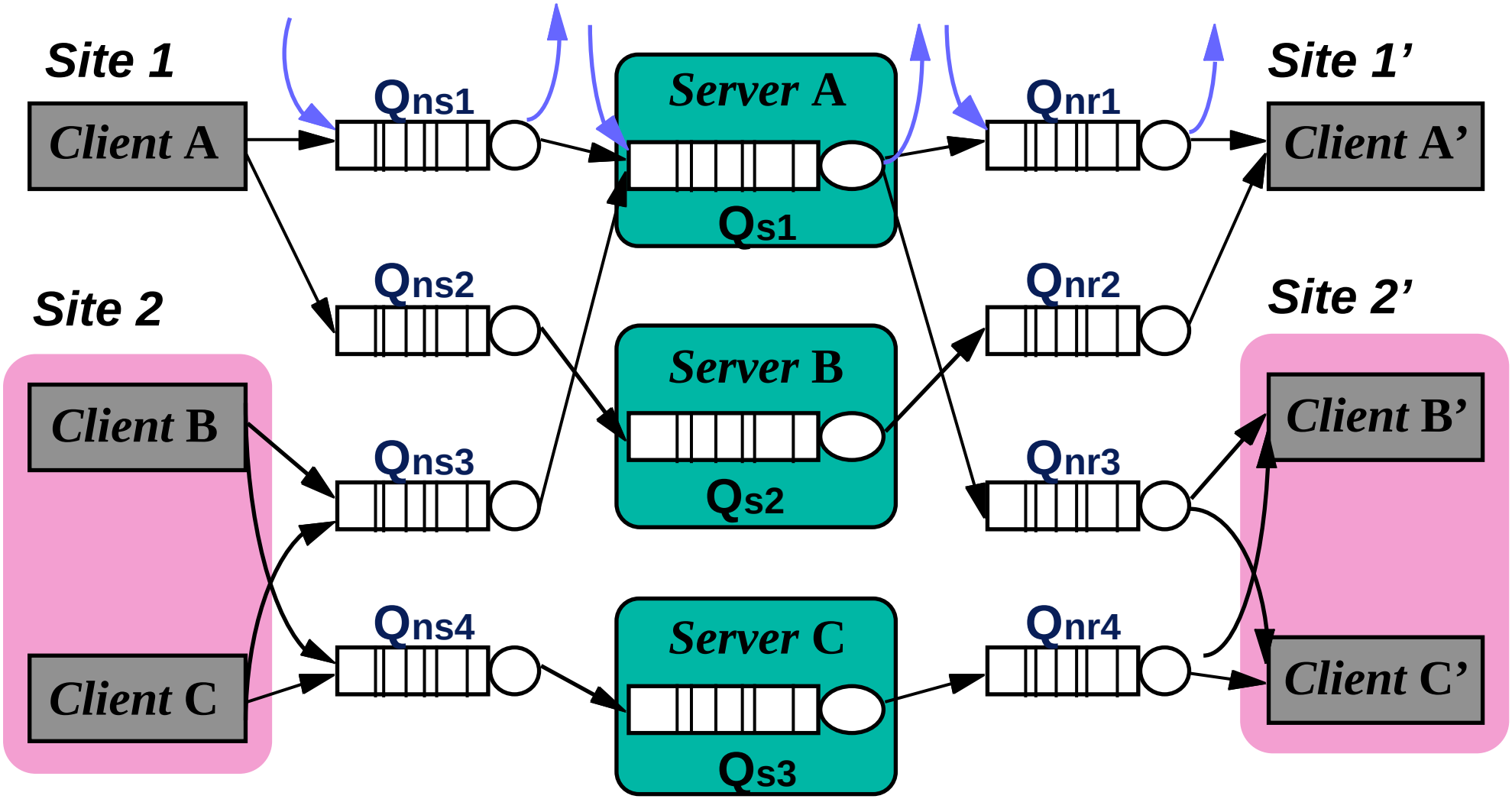
- other jobs

  jobs which are invoked from other processes and enter Qs

- other data

  data which are transmitted from other processes and enter Qns or Qnr

Example of Proposed Model



Clients

Job Invoked by a Client

- data transmitted to the server (Dsend)
- computation of the job
- data transmitted from the server (Drecv)

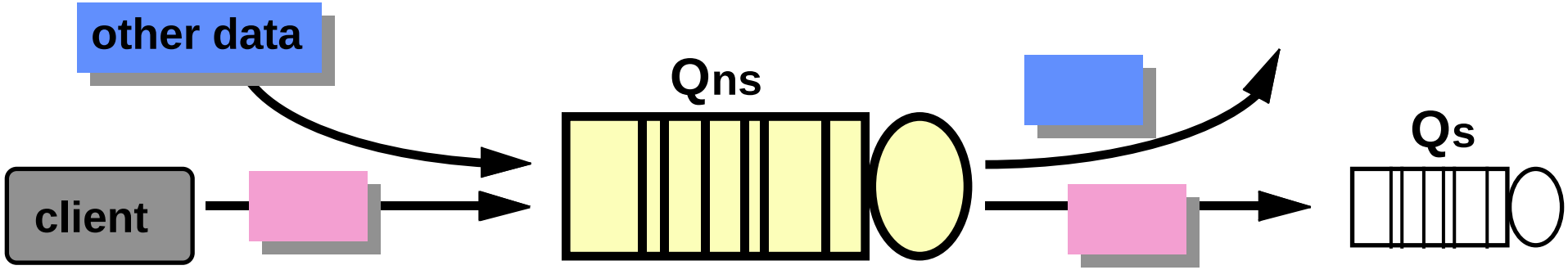
Procedure to Transmit Associated Data

- decompose Dsend into logical packets
- transmit packets to Qns

Procedure to Receive Execution Results

- receive Drecv from Qnr

Queue as a Network (Qns)

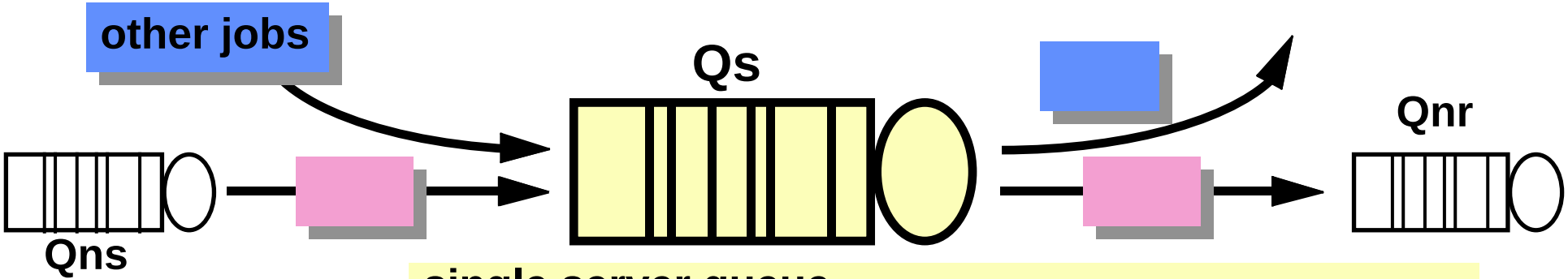


single server queue with finite buffer
FCFS
service rate = Tnet / Wpacket

- A packet transmitted from the client enters Qns.
- A packet is retransmitted when buffer is full.

  → communication throughput
- A packet transmitted from the client leaves for Qs.
- Arrival rate of other data indicates congestion of the network.

Queue as a Server (Qs)



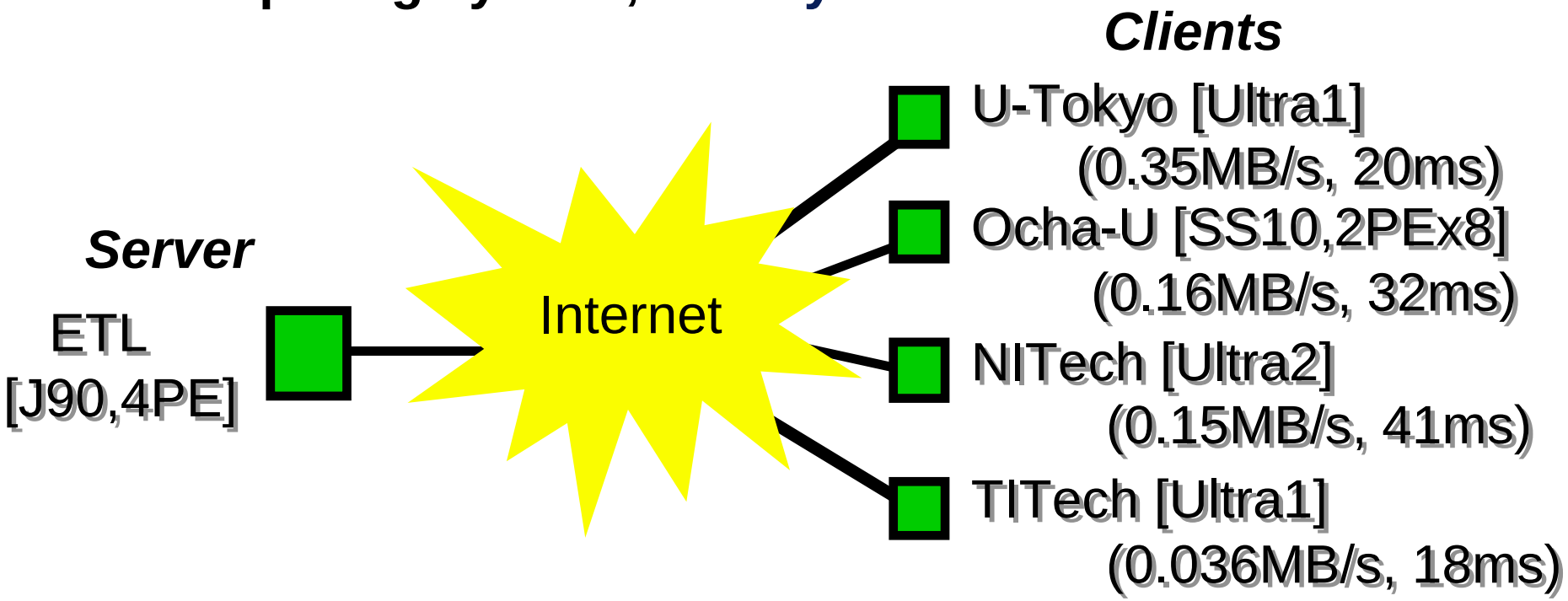
single server queue
FCFS or other strategies
service rate = Tser / Wc
(Tser : server performance, Wc : ave. comput. size)

- The computation of the job enters Qs after all associated data arrive at Qs.
- Queued job waits for its turn. → response time
- Data of results are decomposed into logical packets and these packets are transmitted to Qnr.
- Arrival rate of other jobs indicates congestion on the server.

Verification of the Proposed Model

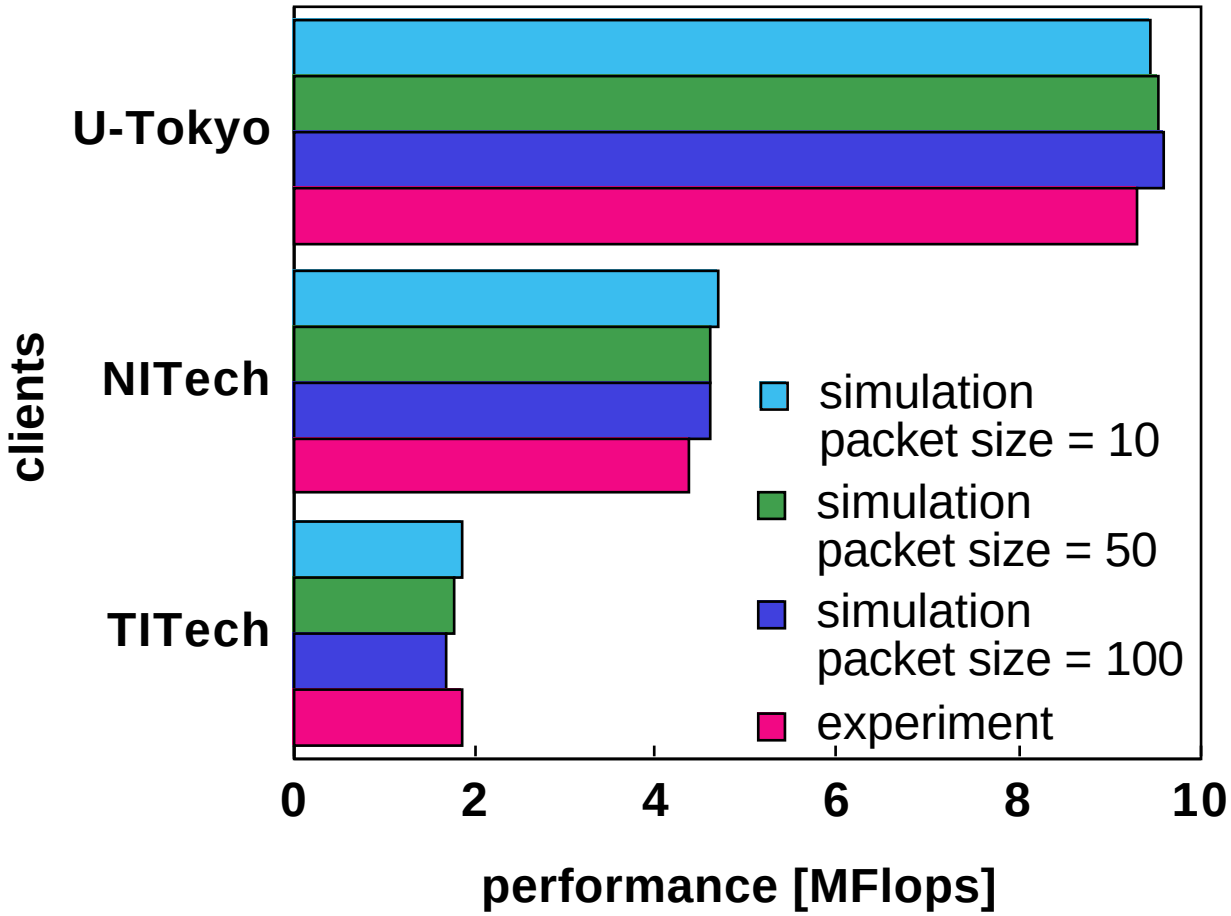
Comparison

- results in simulation on the proposed model
- results in experiments on the actual global computing system, **Ninf system**



Performance of Clients' Jobs

clients : WS in U-Tokyo, NITech and TITech, server : J90 in ETL
clients' jobs :
-Linpack (Comput. = $O(2/3n^3 + 2n^2)$, comm.= $8n^2 + 20n + O(1)$)



- **The performance of jobs invoked by multiclients in the simulation closely matches experimental results.**

- **Effect of different packet sizes is almost negligible.**

Evaluation of Job Scheduling Schemes

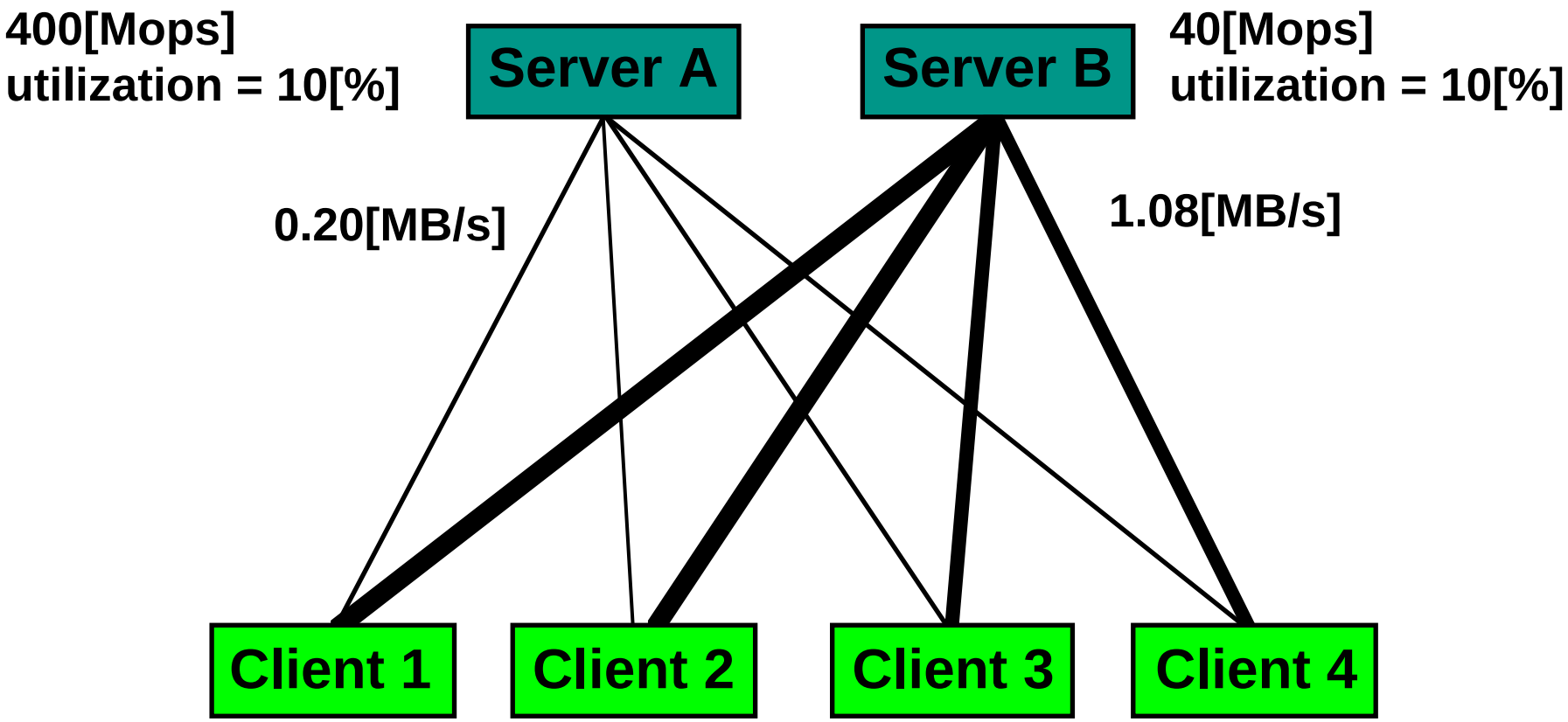
Evaluation

- Evaluation of job scheduling schemes on imaginary environment in the simulation on the proposed model

Job Scheduling Schemes

- RR round robin
- LOAD server load
- LOTH server load + network load

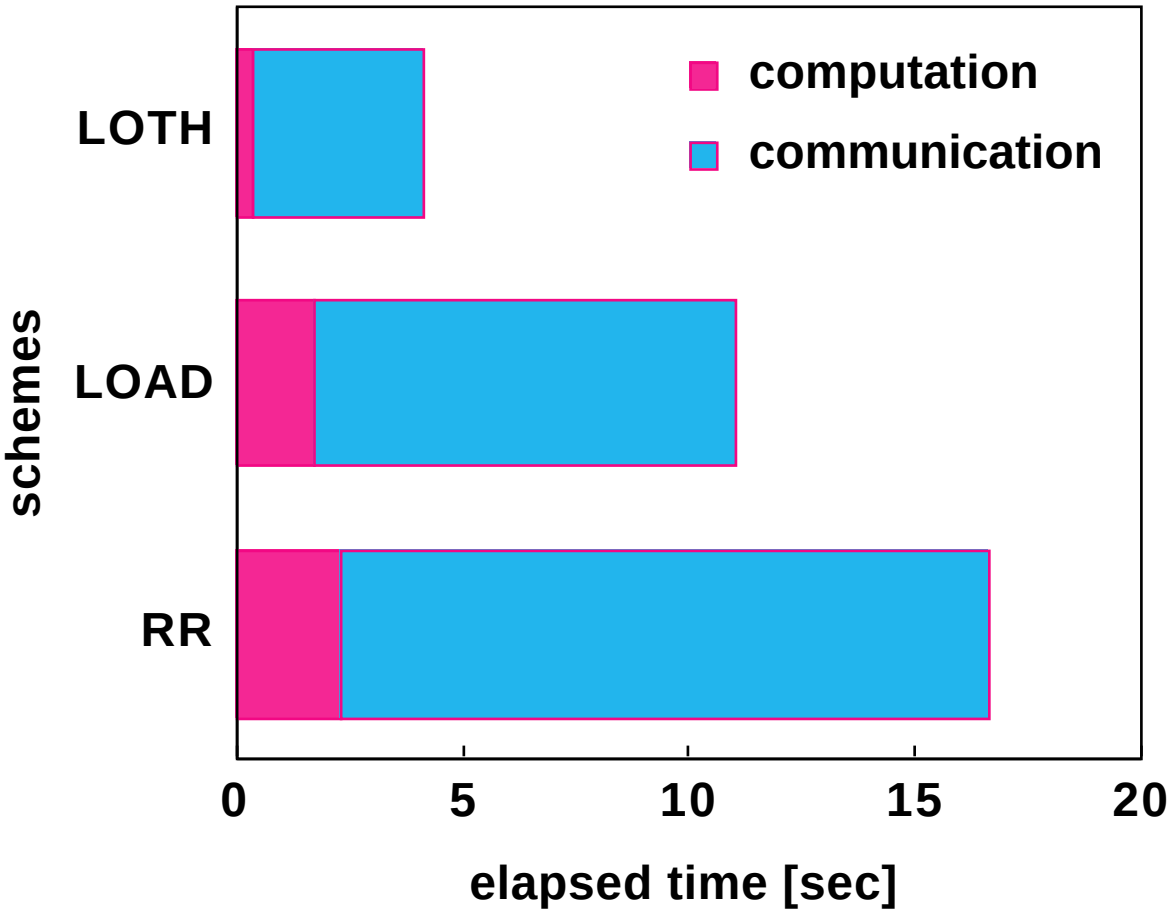
Imaginary Environment



Job Scheduling Performance

clients' jobs

-Linpack (Comput. = $O(2/3n^3 + 2n^2)$, comm.= $8n^2 + 20n + O(1)$)



LOAD causes network congestion and degrades the performance.

LOTH shows best performance.

Both a server load and a network load should be employed.

Conclusions

Proposal

- performance evaluation model for effective job scheduling in global computing systems

Verification and Evaluation of the Model

- The proposed model could effectively simulate the performance of clients' jobs in simple setup of the actual global computing system, Ninf system.
- Dynamic information of both servers and networks should be employed for job scheduling.

Future Work

- better modeling of changeability of network congestion