Overview of a Performance Evaluation System for Global Computing Scheduling Algorithms

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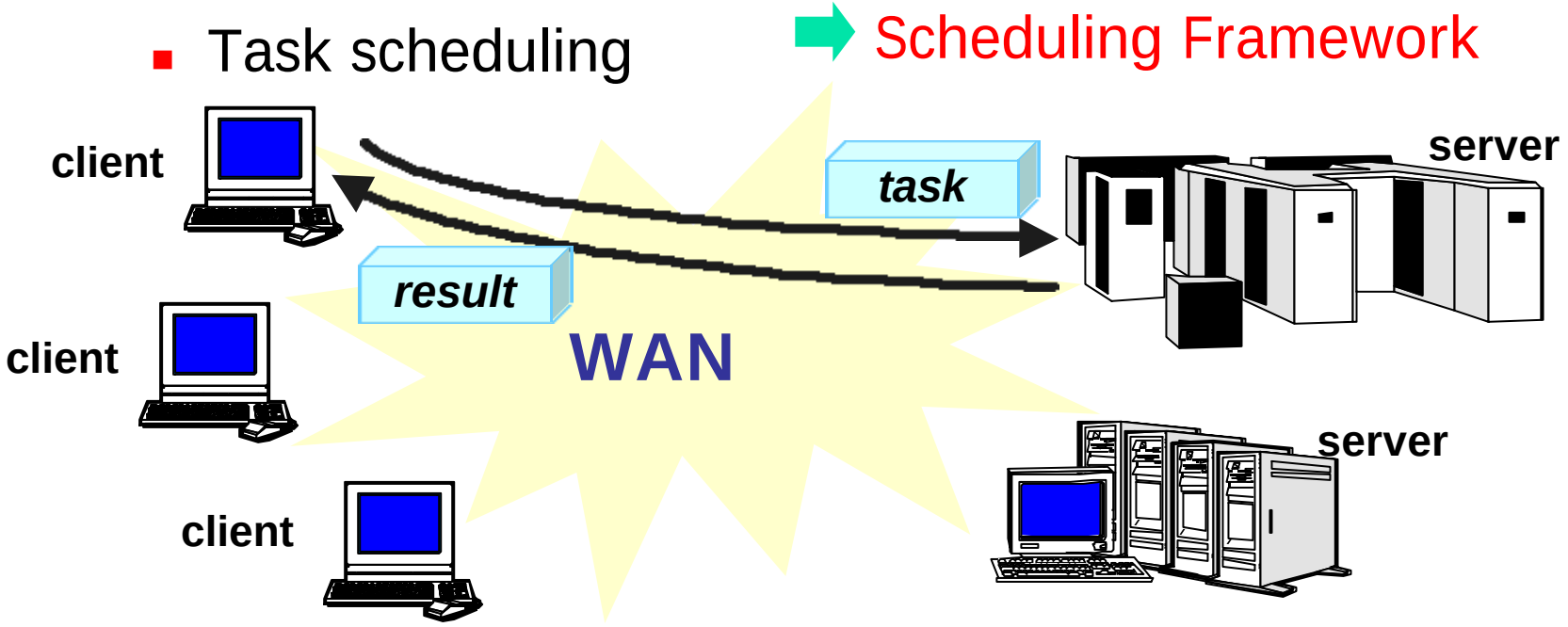
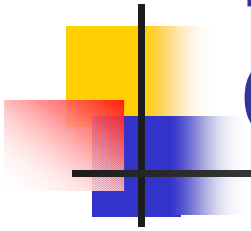
http://ninf.is.titech.ac.jp/bricks/

Global Computing System

- High performance global computing using computational and data resources
- Effective use of resources
  - Resource monitoring and prediction
  - Task scheduling

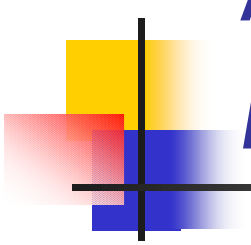


Evaluation of Scheduling in Global Computing

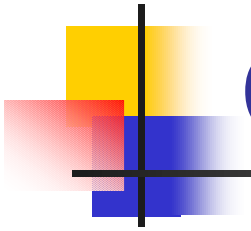


- Unrealistic to compare scheduling algorithms w/physical benchmarks
  - Reproducible large scale benchmarks are too difficult under various
    - Networks - topology, bandwidth, congestion, variance
    - Servers - architecture, performance, load, variance
- Validity of scheduling framework modules have not been well-investigated.
  - Benchmarking cost of monitor / predictor under real environment *HIGH*

A Performance Evaluation System: *Bricks*

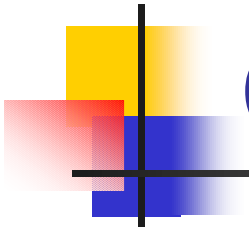


- Performance evaluation system for
  - Global computing scheduling algorithms
  - Scheduling framework components
    (e.g., sensors, predictors)
- Bricks provides
  - Reproducible and controlled evaluation environments
  - Flexible setups of simulation environments
  - Evaluation environment for existing global computing components (e.g., NWS)



Outline

- Overview of the Bricks system
- The Bricks architecture
- Incorporating existing global computing components (ex. NWS)
- Bricks experiments

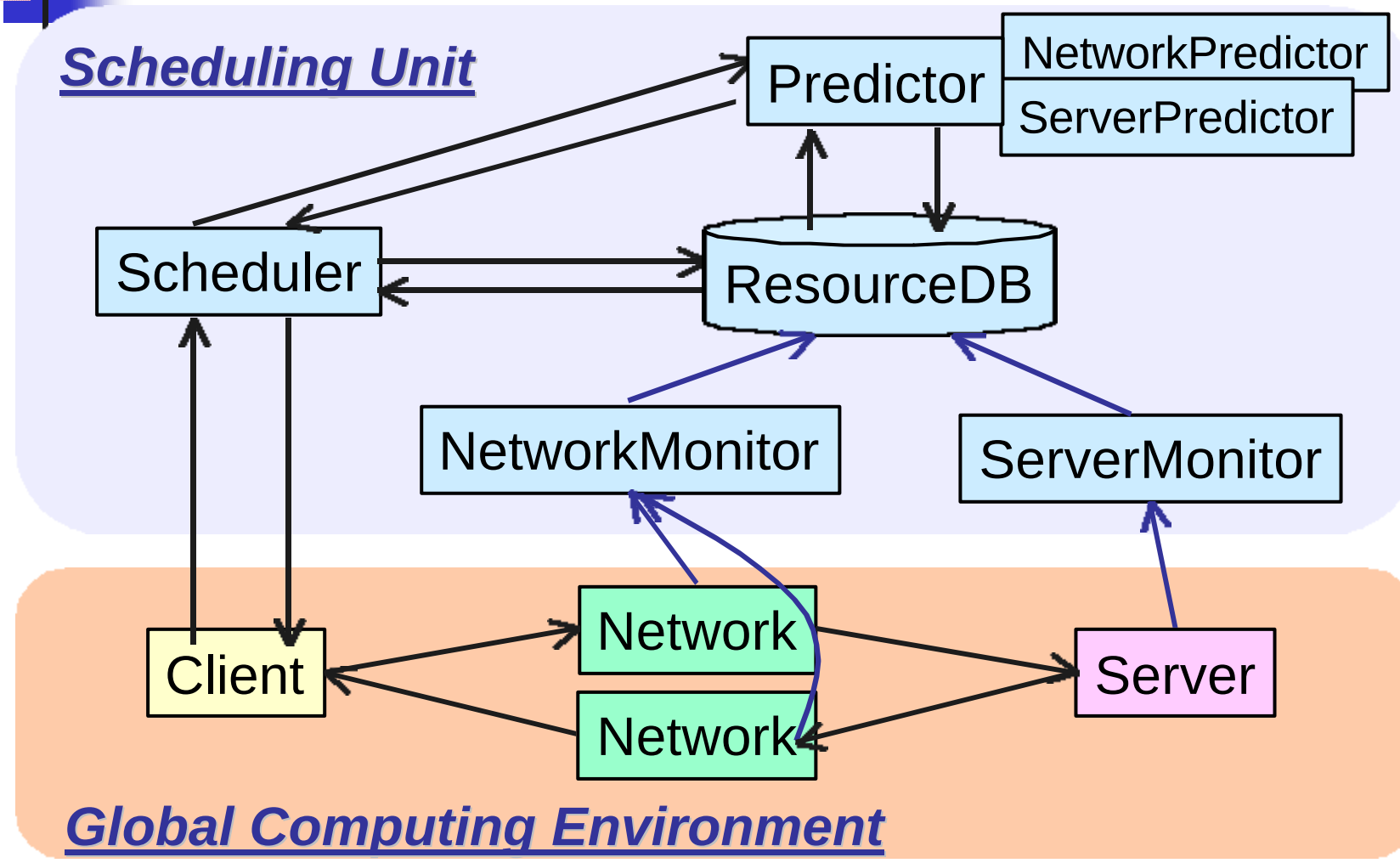


Overview of Bricks

- Consists of simulated *Global Computing Environment* and *Scheduling Unit.*
- Allows simulation of various behaviors of
  - resource scheduling algorithms
  - programming modules for scheduling
  - network topology of clients and servers
  - processing schemes for networks and servers (various queuing schemes)

  using the *Bricks script*.
- Makes benchmarks of existing global scheduling components available

The Bricks Architecture



Global Computing Environment

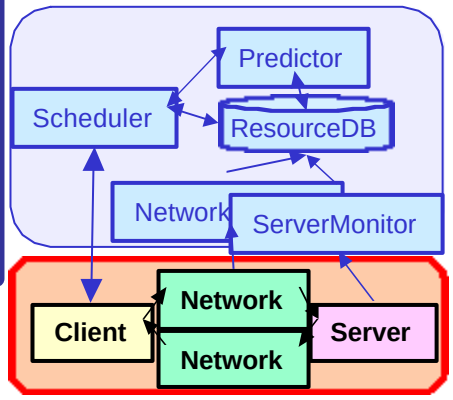
- Client
  - represents user of global computing system
  - invokes global computing Tasks

    Amount of data transmitted to/from server,

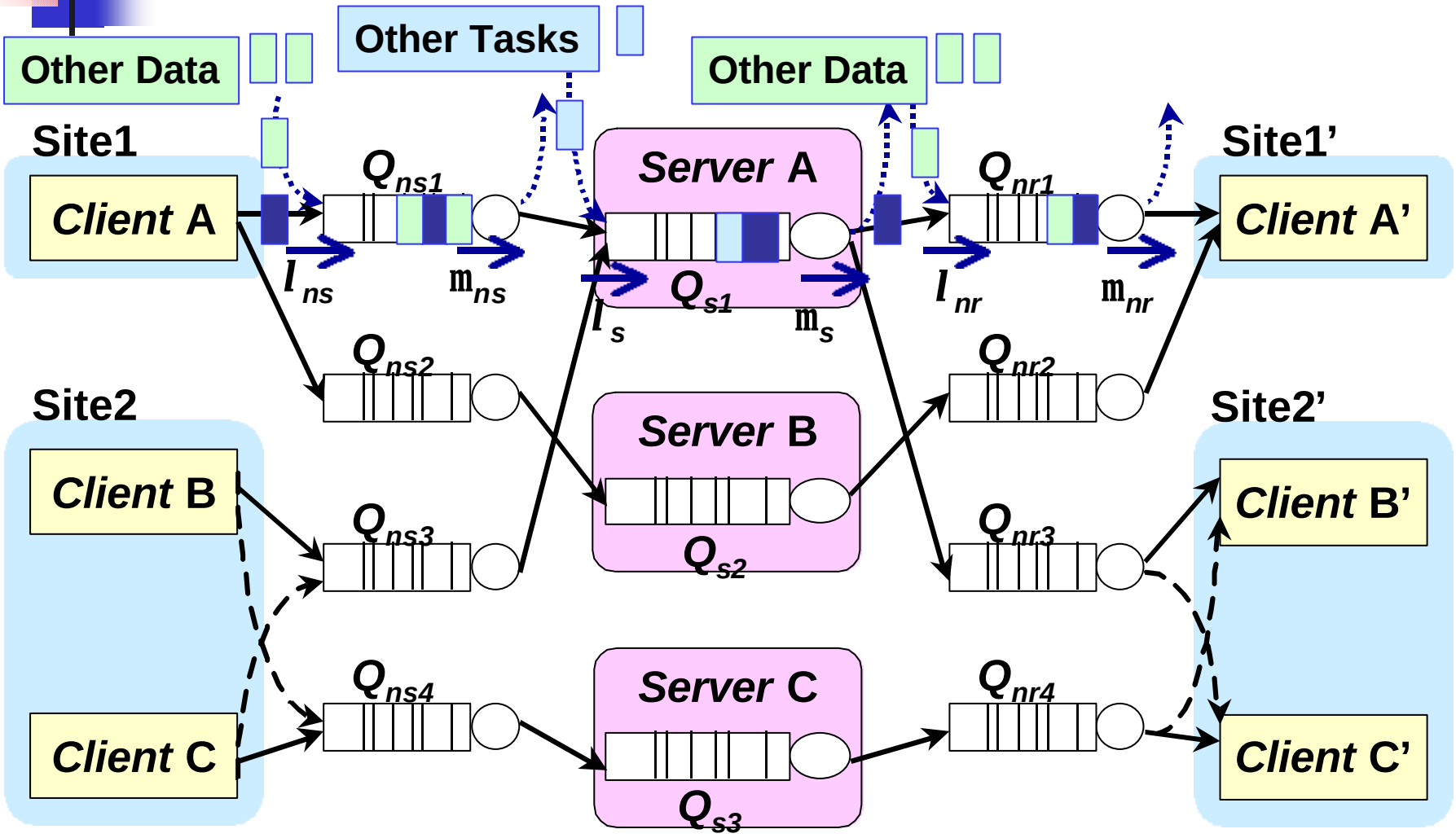
    # of executed instructions

- Server
  - represents computational resources
- Network
  - represents the network interconnecting the Client and the Server

Represented using queues



Queuing Model-based Global Computing Simulation [NASA Workshop 98]



Communication/Server Models using queues in Bricks

- Extraneous data/jobs generation

  Congestion represented by adjusting the amount of arrival data/jobs from other nodes/users [NASA Workshop98]

  ○ Need to specify only several parameters
  ✕ Greater accuracy requires larger simulation cost

- Observed parameters

  Bandwidth/performance at each step = observed parameters of real environment.

  ○ Network/Server behaves as if real network/server
  ○ Simulation cost lower than the previous model
  ✕ Need to accumulate the measurements

Scheduling Unit

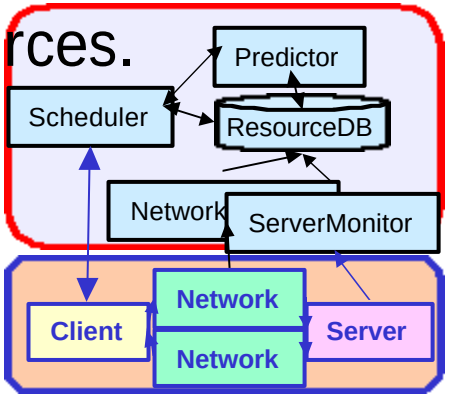
- NetworkMonitor/ServerMonitor

  measures/monitors network/server status in global computing environments
- ResourceDB

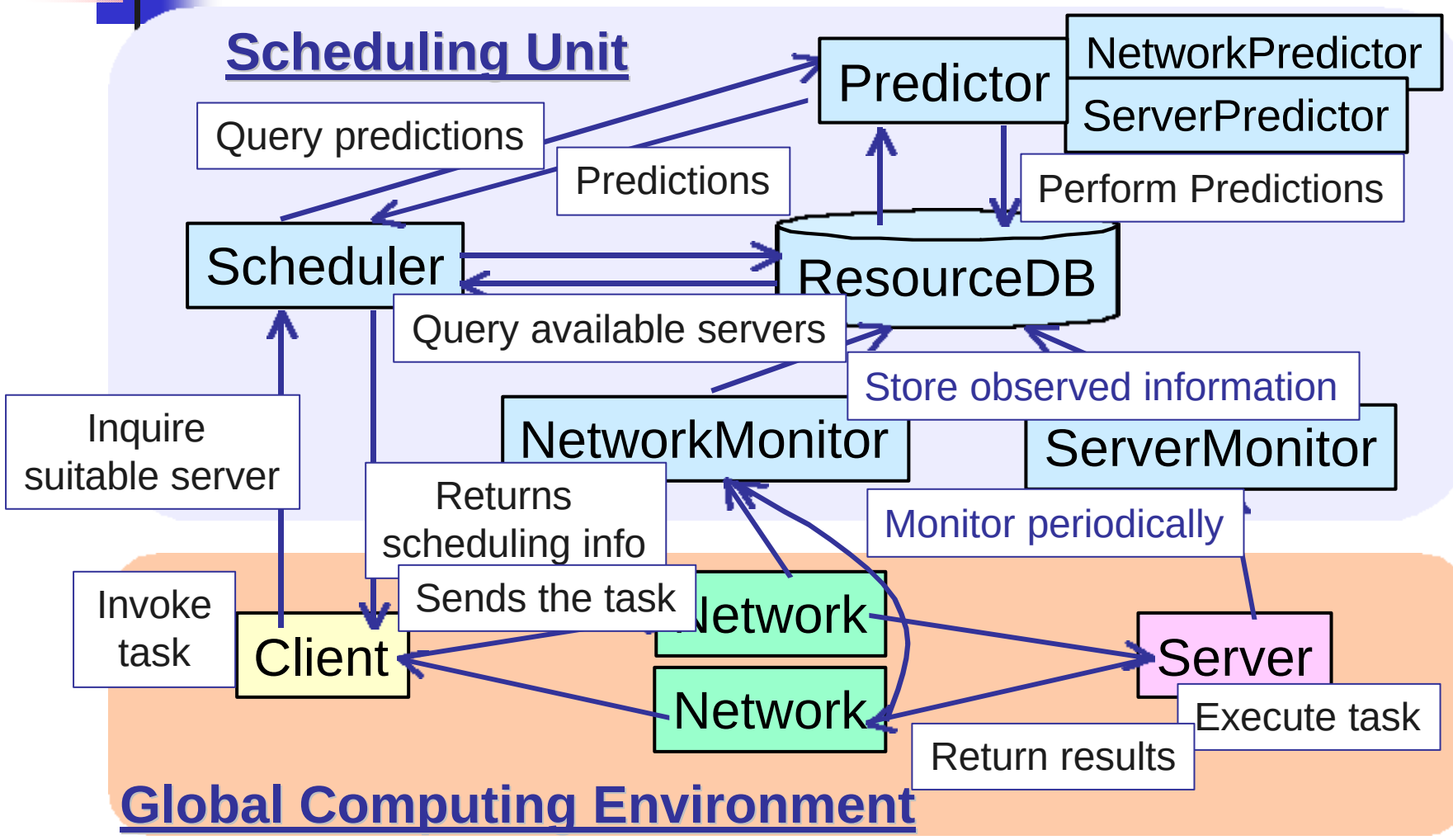
  serves as scheduling-specific database, storing the values of various measurements.
- Predictor

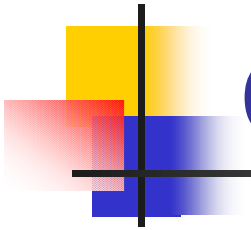
  reads the measured resource information from ResourceDB, and predicts availability of resources.
- Scheduler

  allocates a new task invoked by a client on suitable server machine(s)



Overview of Global Computing Simulation with Bricks





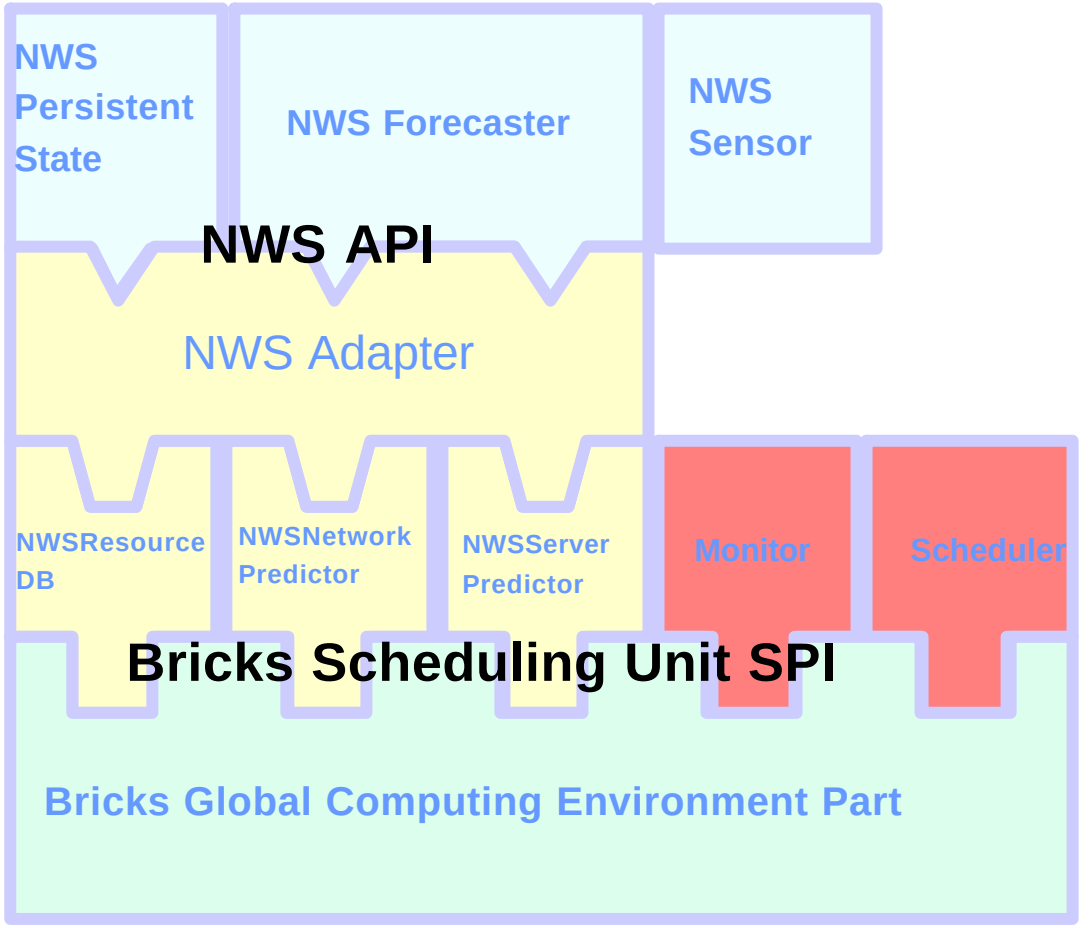
Incorporating External Components

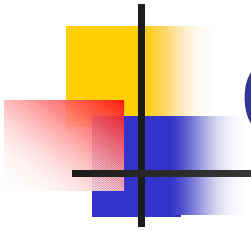
- Scheduling Unit module *replacement*
  - Replaceable with other Java scheduling components
  - Components could be external --- in particular, real global computing scheduling components

  →allowing their validation and benchmarking under simulated and reproducible environments
- Bricks provides the Scheduling Unit SPI.

Scheduling Unit SPI

```
interface ResourceDB {
      void putNetworkInfo();
      void putServerInfo();
      NetworkInfo getNetworkInfo();
      ServerInfo getServerInfo();
}
interface NetworkPredictor {
      NetworkInfo getNetworkInfo();
}
interface ServerPredictor {
      ServerPredictor getServerInfo();
}
interface Scheduler {
      ServerAggregate selectServers();
}
```





Case study

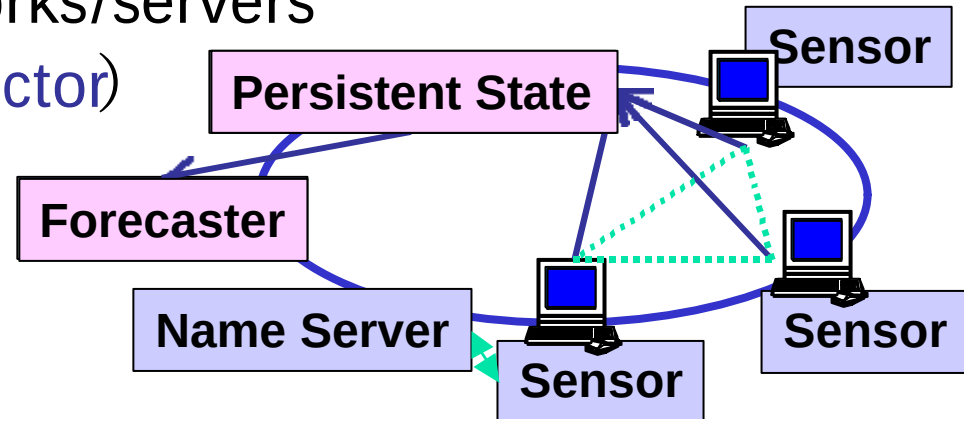
- NWS[UCSD] integration into Bricks
  - monitors and predicts the behavior of global computing resources
  - has been integrated into several systems, such as AppLeS, Globus, Legion, Ninf
  - Orig. C-based API

    → NWS Java API development

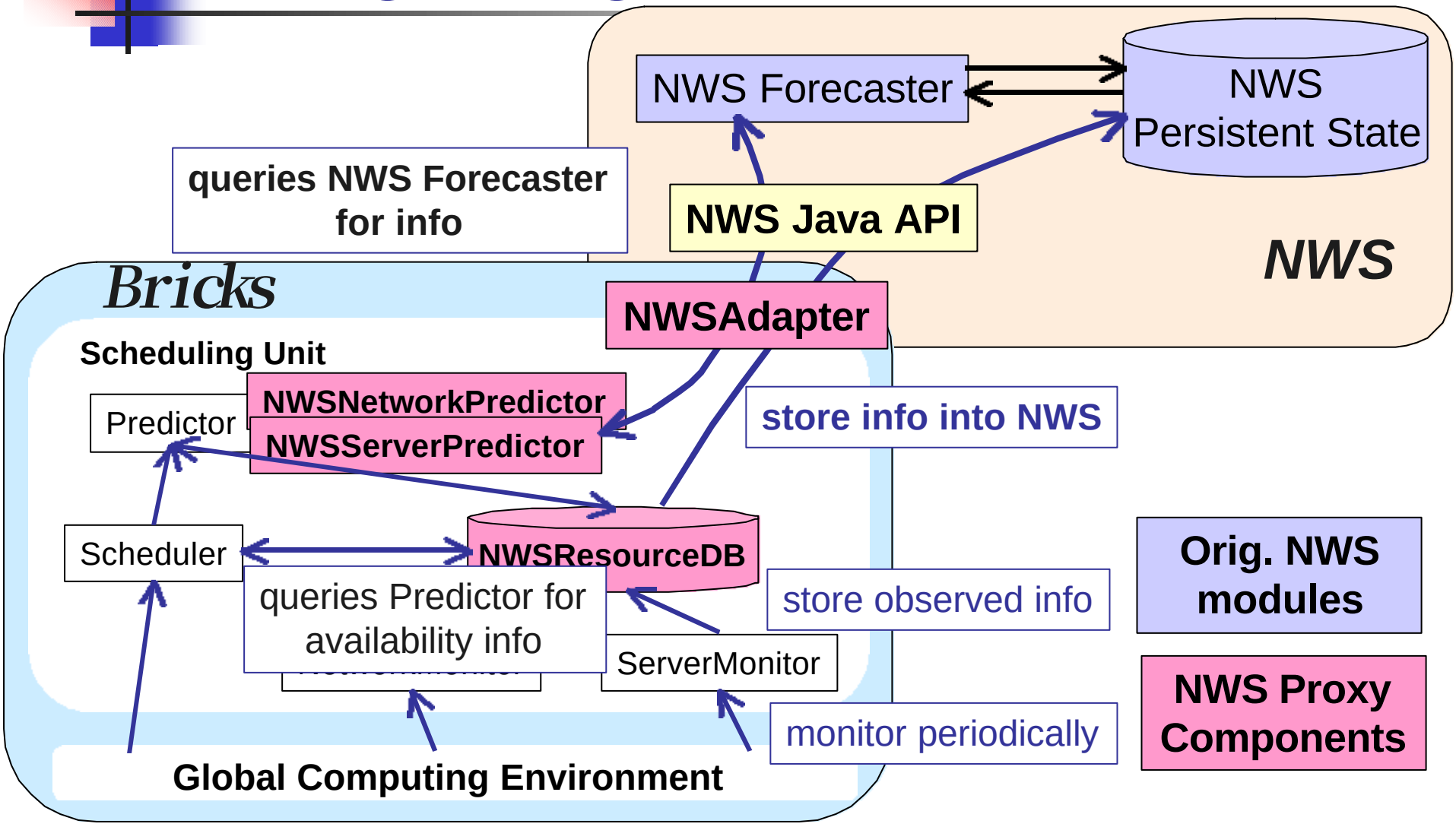
    → NWS run under Bricks

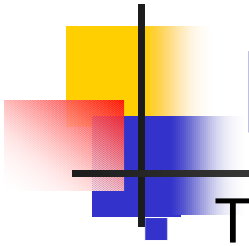
The NWS Architecture

- Persistent State (→Replace ResourceDB)
  is storage for measurements
- Name Server
  manages the correspondence between the IP/domain address for each independently-running modules of NWS
- Sensor (→Network/ServerMonitor)
  monitors the states of networks/servers
- Forecaster (→ Replace Predictor)
  predicts availability of the resources



Integrating NWS into Bricks





Bricks Experiments

- The experiments conducted by running NWS under a real environment vs. Bricks environment

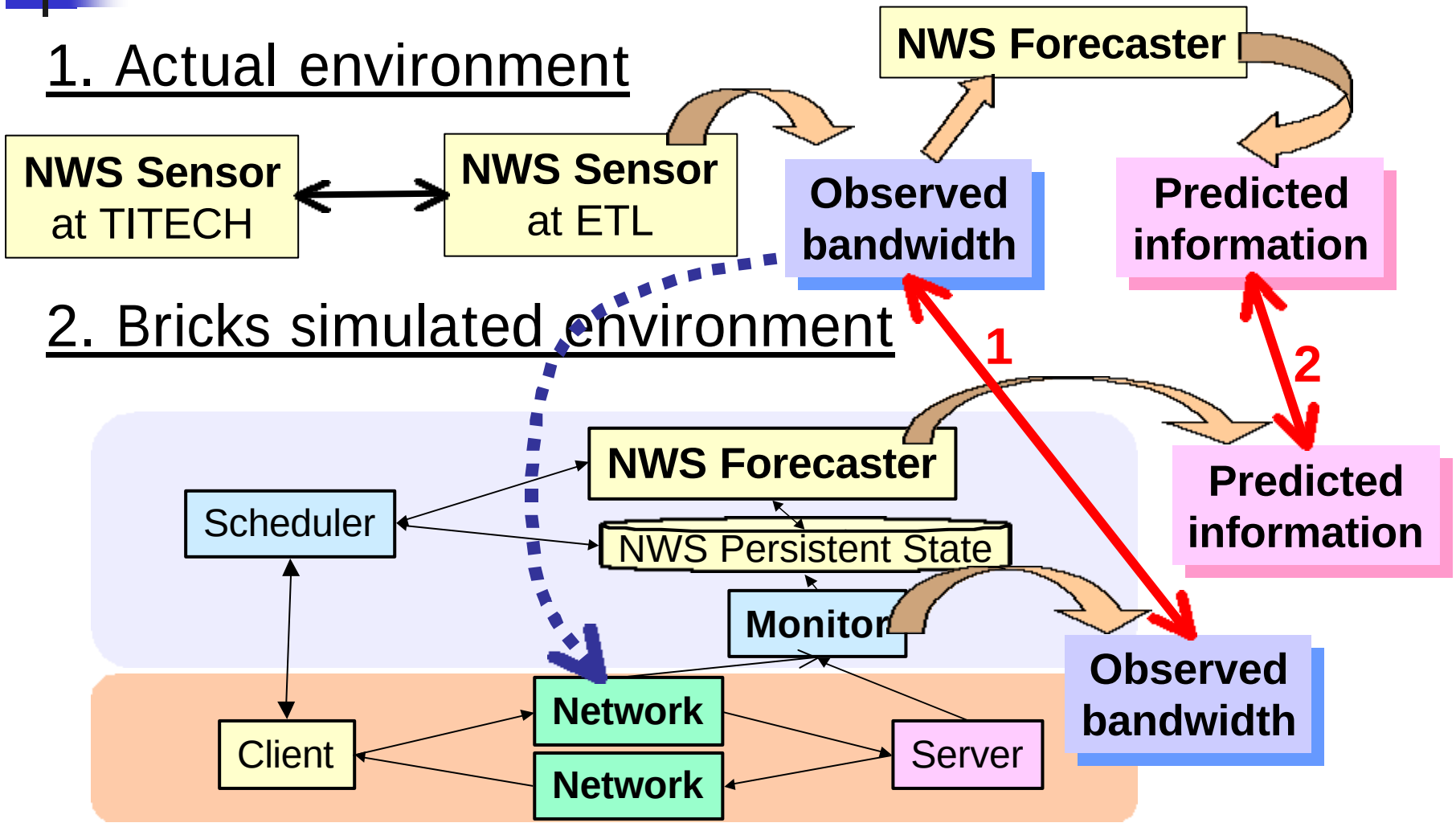
  Whether can Bricks provide

  - A simulation environment for global computing with reproducible results?
  - A benchmarking environment for existing global computing components?

- Experiment Procedure

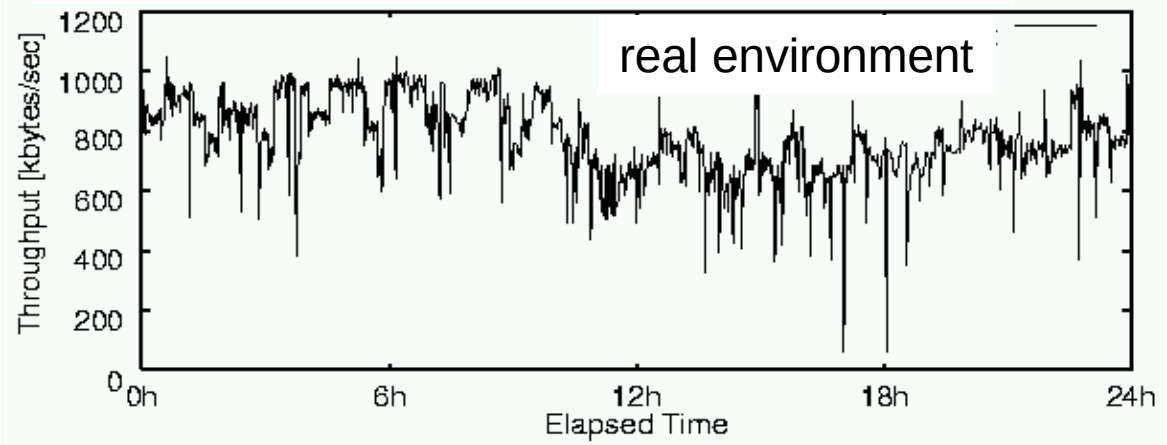
  1. Actual measurement: Have NWS modules measure and predict parameters real wide-area environment
  2. Simulation: Drive Bricks under the NWS measurements, and have NWS Forecaster make predictions under Bricks simulation

Overview of Experiments



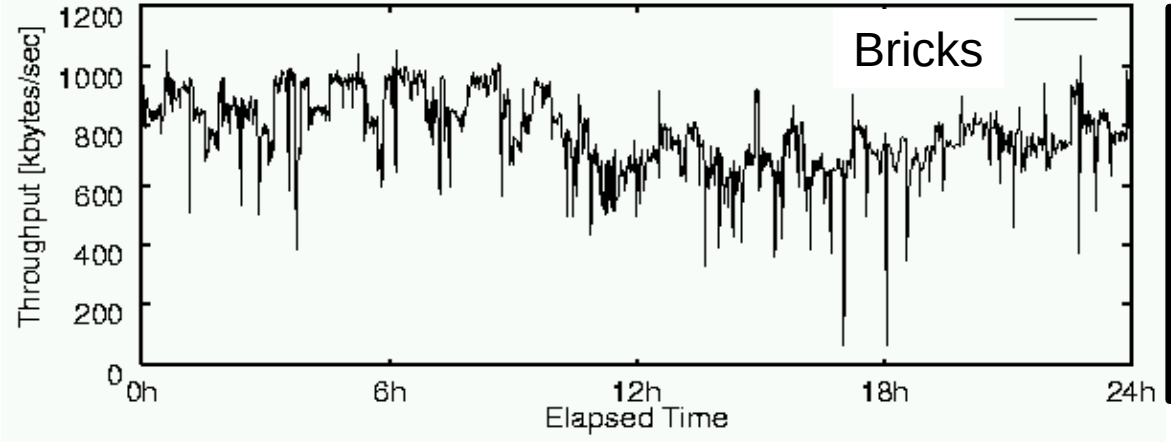
Bricks Experimental Results 1: Comparison of Observed Bandwidth

Under real environment(24hours)



- The Bandwidth measured under Bricks is quite similar to that for the real environment

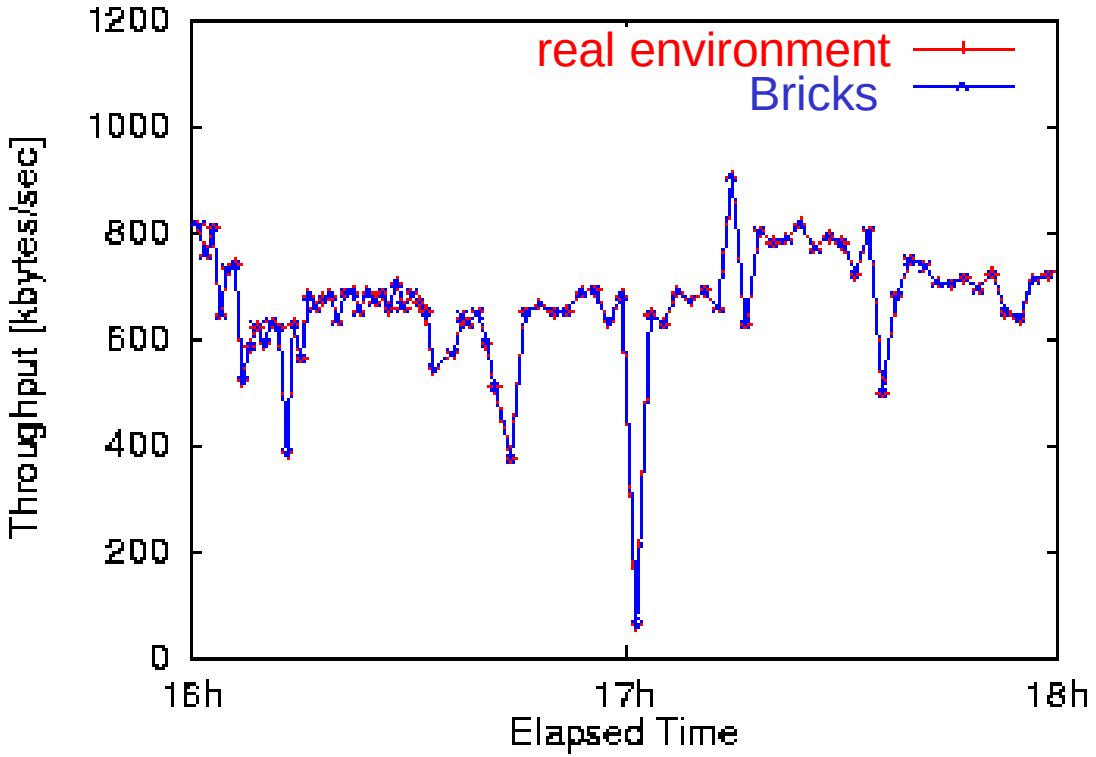
Under Bricks simulated environment(24hours)



NWS:
TITECH ⇔ ETL
network monitoring: 60[sec]
network probe :300[KB]
Bricks:
cubic spline interpolation

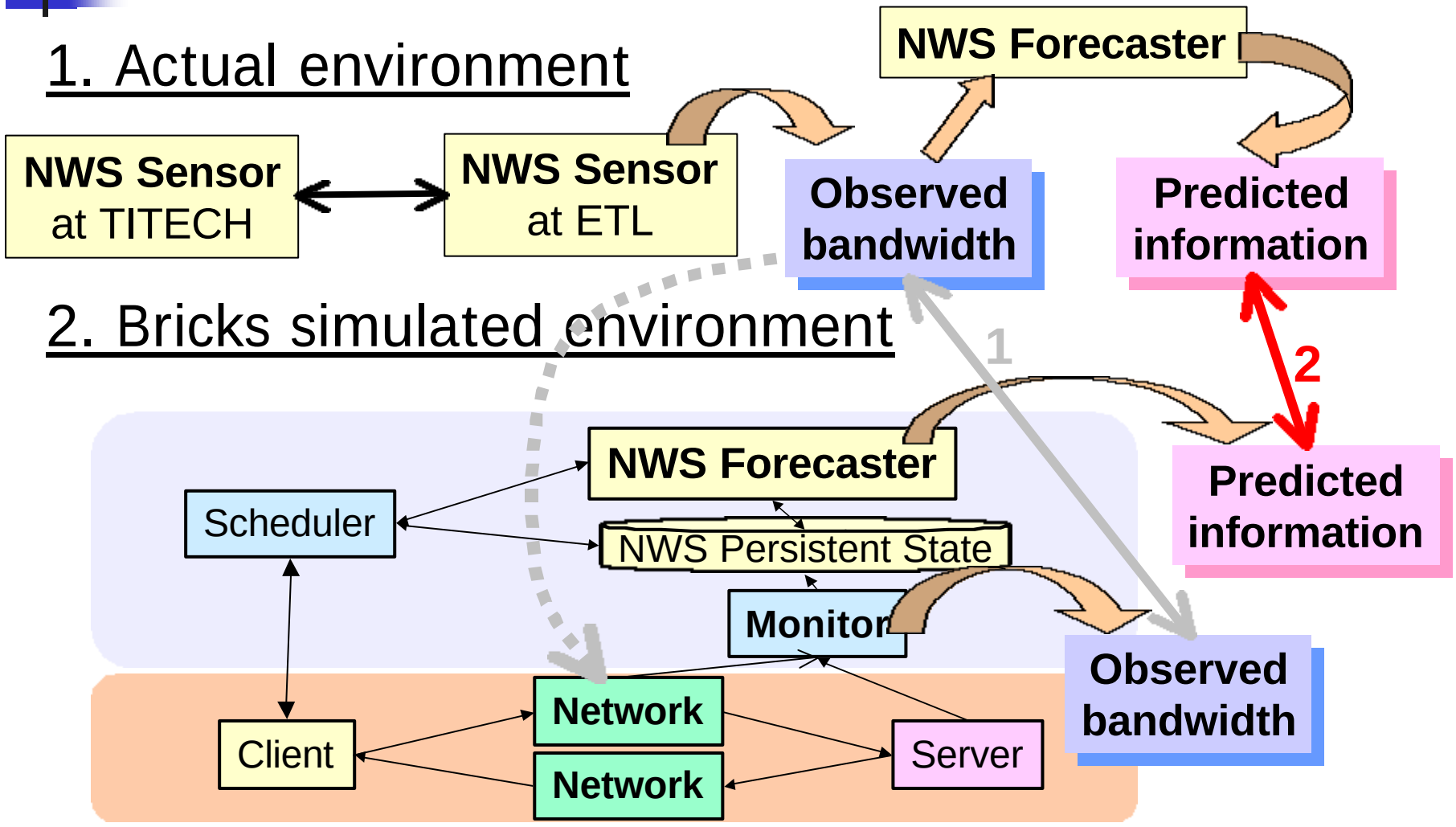
Bricks Experimental Results 1: Comparison of Observed Bandwidth

2 hours comparison



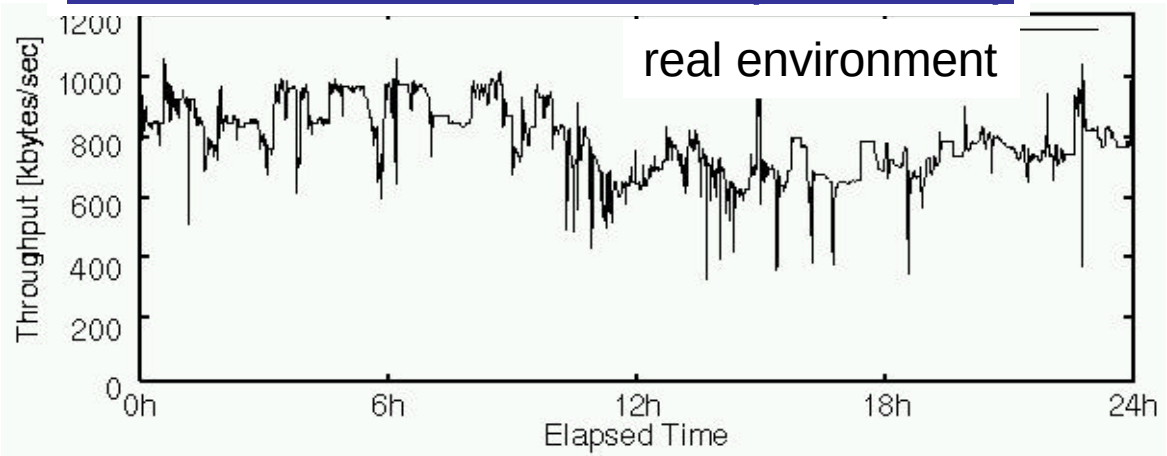
- Bandwidths measured under real environment and Bricks coincide well

Overview of Experiments

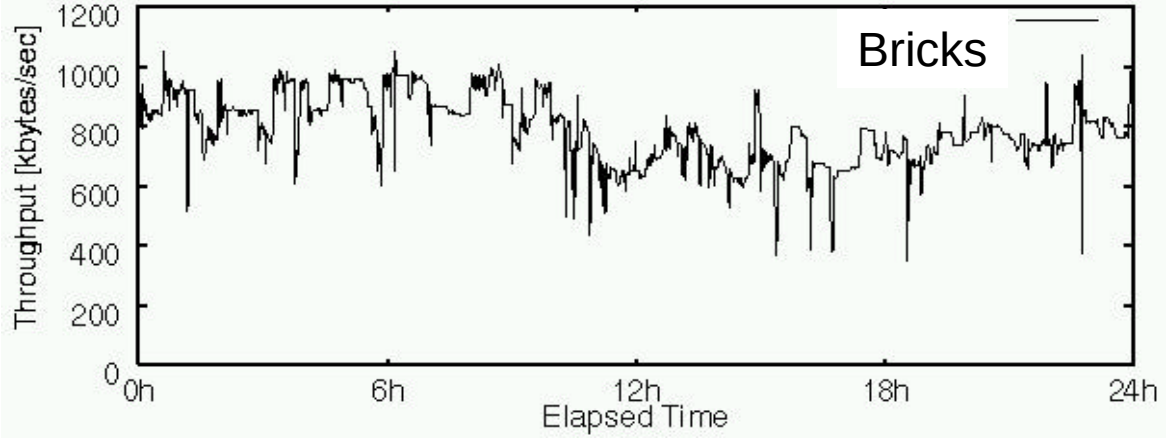


Bricks Experimental Results 2: Comparison of Predicted Bandwidth

Under real environment(24hours)



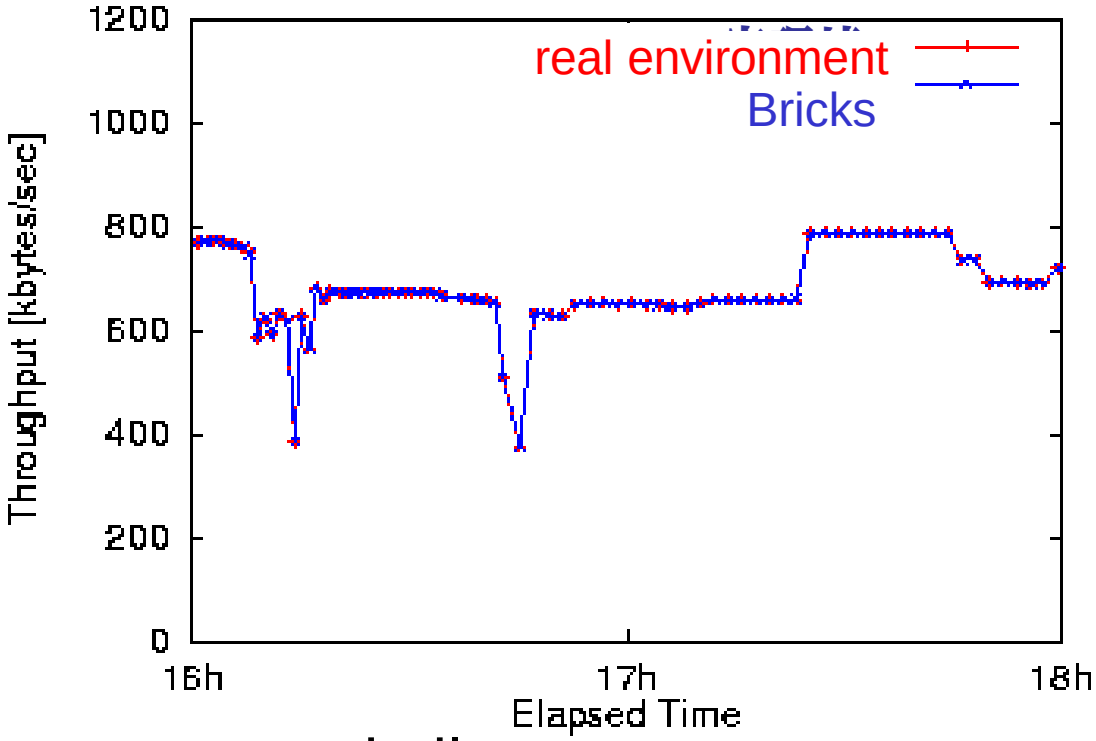
Under Bricks (24hours)



- The NWS Forecaster functions and behaves normally under Bricks

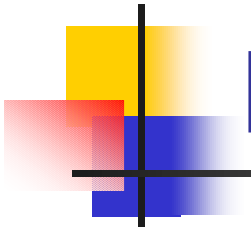
Bricks Experimental Results 2: Comparison of Predicted Bandwidth

2 hours comparison of predicted bandwidth by the NWS Forecaster



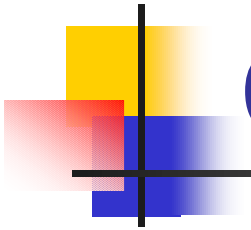
- The both predictions are very similar.

® Bricks provides existing global computing components with a benchmarking environment



Related Work

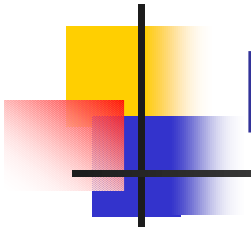
- Osculant Simulator[Univ. of Florida]
  - evaluates Osculant: bottom-up scheduler for heterogeneous computing environment
  - makes various simulation settings available
- WARMstones [Syracuse Univ.]
  - is similar to Bricks, although it seems not have been implemented yet?
  - provides an interface language(MIL) and libraries based on the MESSIAHS system to represent various scheduling algorithms →Bricks provides SPI
  - has not provided a benchmarking environment for existing global computing components



Conclusions

- We proposed the Bricks performance evaluation system for global computing scheduling
  - Bricks provides multiple simulated reproducible benchmarking environments for
    - Scheduling algorithms
    - Existing global computing components
- Bricks experiments showed
  - Bricks could perform accurate simulation
  - The NWS Forecaster behaved normally under Bricks

  → Evaluation of existing global computing components now possible

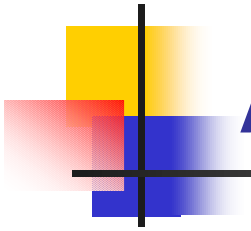


Future Work

- Simulation model needs to be more sophisticated and robust
  - Task model for parallel application tasks
  - Server model for various server machine architectures(e.g., SMP, MPP) and scheduling schemes(e.g., LSF)
- Component integration (e.g., direct support for IP)
- Investigation of various scheduling algorithms
  - On parallel simulation cluster

Cluster

- 64PE cluster at Matsuoka Lab., TITECH
  - Pentium II 350MHz
  - Memory: 128MB
  - NIC: Intel EtherExpress Pro 10/100
- Parallel simulations of global computing environments



Acknowledgments

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  - Rich Wolski [UTK]
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  - Mitsuhisa Sato [RWCP]
  - Many others [ETL, TITECH]