VLBI Data Transmission System using Multiple IP Streams

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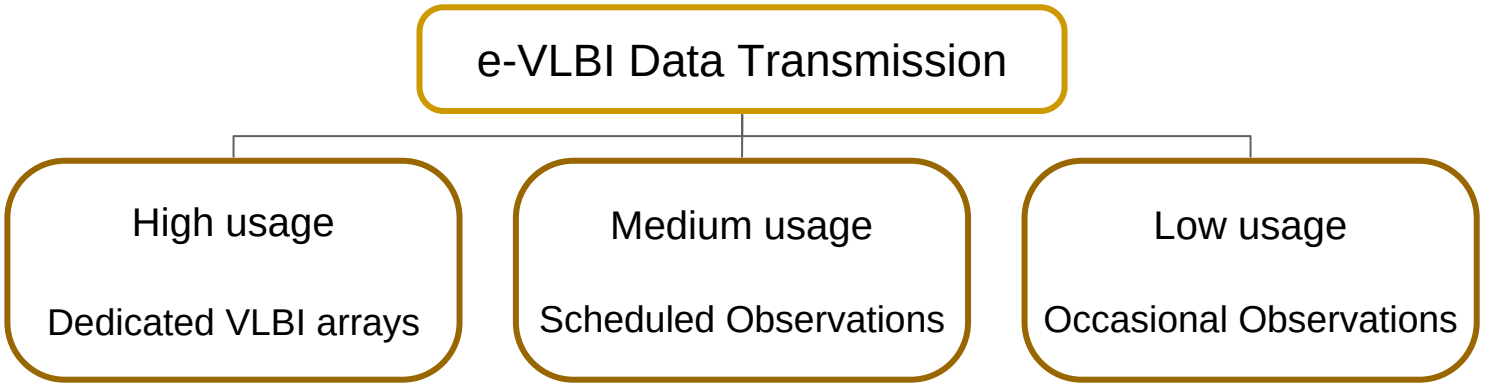
Data Transmission Technologies for e-VLBI



Example:	KSP, NMA?	GALAXY	Kashima-Haystack Observations

Suitable Technologies:

Dedicated Networks with dedicated BW	Shared Netw…
ATM, SONET or Lambda	Inte…
•Reliable but rigid and expensive •Direct mapping of data to reliable "pipes" with guaranteed bandwidth	•Not reliable but flexible a…d economical •Needs complicated processing (error correction, congestion control, etc.)

Multiple IP stream scheme

IP Technologies for e-VLBI

- Advantages
  - Utilization of “off-the-shelf” equipment
    - PCs, routers, L2 switches, High-speed I/Os, etc...
  - Existing resources (R&E networks with vast bandwidth)
    - Sharing resources with other BW eating applications
  - Improved connectivity with other observation sites
    - With IP longer baseline becomes easier
    - Choice of antenna will be wider
  - Compatibility to distributed processing schemes and flexible data retrieval / mining schemes
    - No data conversion required
- Disadvantages
  - QoS is hard to guarantee
  - Complicated processing (error control, realignment of data packets etc.) necessary

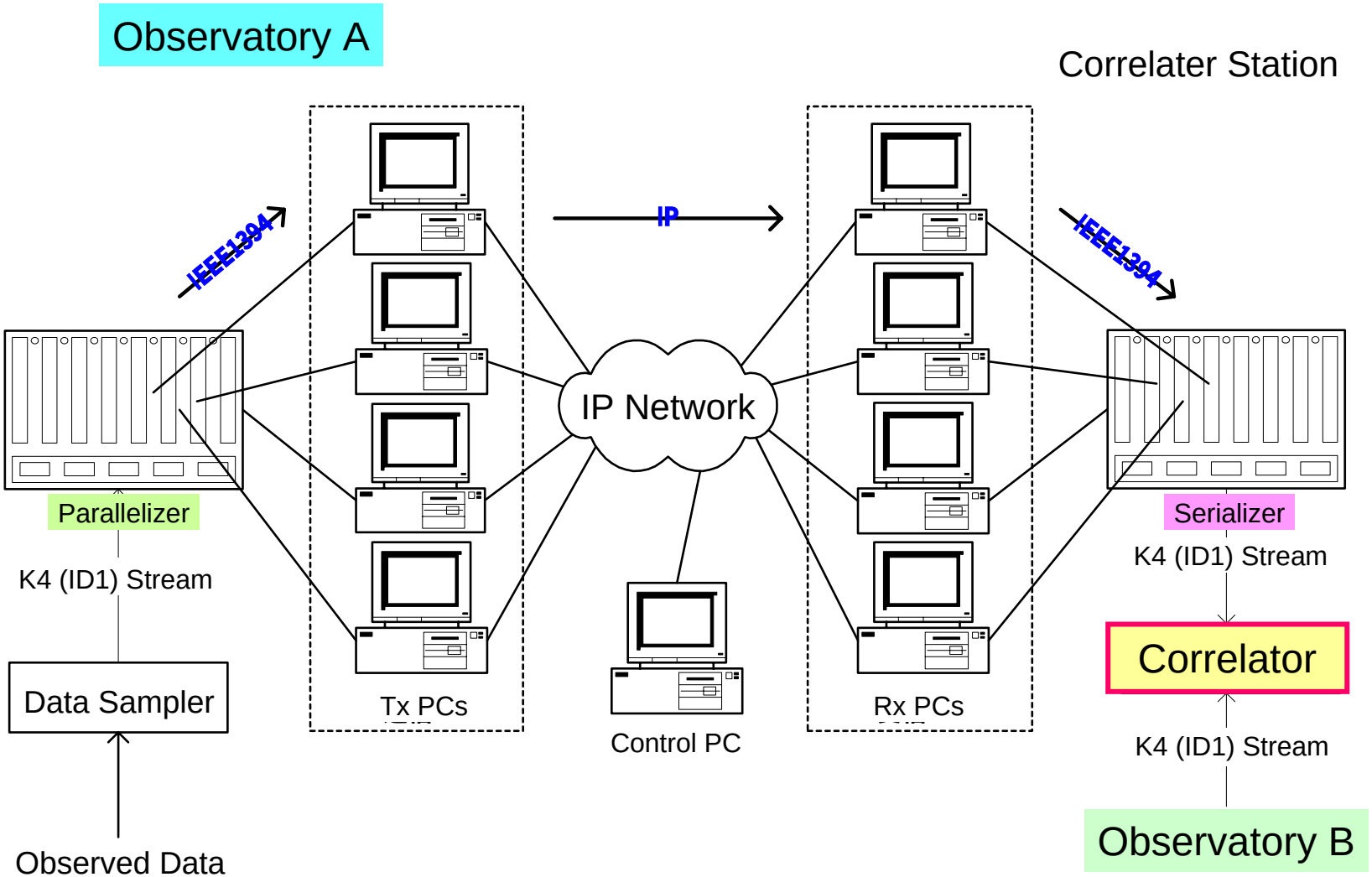
Idea: Reliable K4 cable over shared IP network

- Direct K4 replacement as the old ATM system does
  - Transparent ~256Mb/s data stream transmission
  - Can be upgraded to VSI compatible by changing the I/O units
- Inexpensive and scalable architecture
  - Use of inexpensive PCs (2 streams/PC)
  - Maximum 16 streams
  - Special hardware to interconnect K4 interface and PCs
  - Use of commercial interface standard (IEEE1394)
- Multiple operation modes
  - UDP mode (for networks with small congestion)
  - TCP batch mode (for congested network/short observation)
  - TCP stream mode (for congested network/longer observation)
- Ease of use
  - Centralized control application with GUI
  - Automatic delay adjustment (not implemented yet)

Use of Multiple IP Streams

- Dealing with the latency problem
  - Accomplish high data rates with the use of multiple streams even under large latency environments
  - Suitable for international experiments
  - And have a nice share of the bandwidth at the same time..
- Dealing with the congestion problem
  - UDP mode assures time alignment with loss detection
  - TCP mode assures the reliability with built-in error control
  - Adjustable large buffer memories (disks) at both Tx/Rx sides
- Compatibility to software parallel correlation
  - Receiving PCs can store data in ordinary Unix file format
  - Can be used as a job dispatcher for distributed correlation
  - Why bother to send one very high-speed data stream if you have to chop up the stream into many fragments of data to be processed in parallel?

Multiple Stream VLBI Data Transfer System



Transmitting and Receiving Data

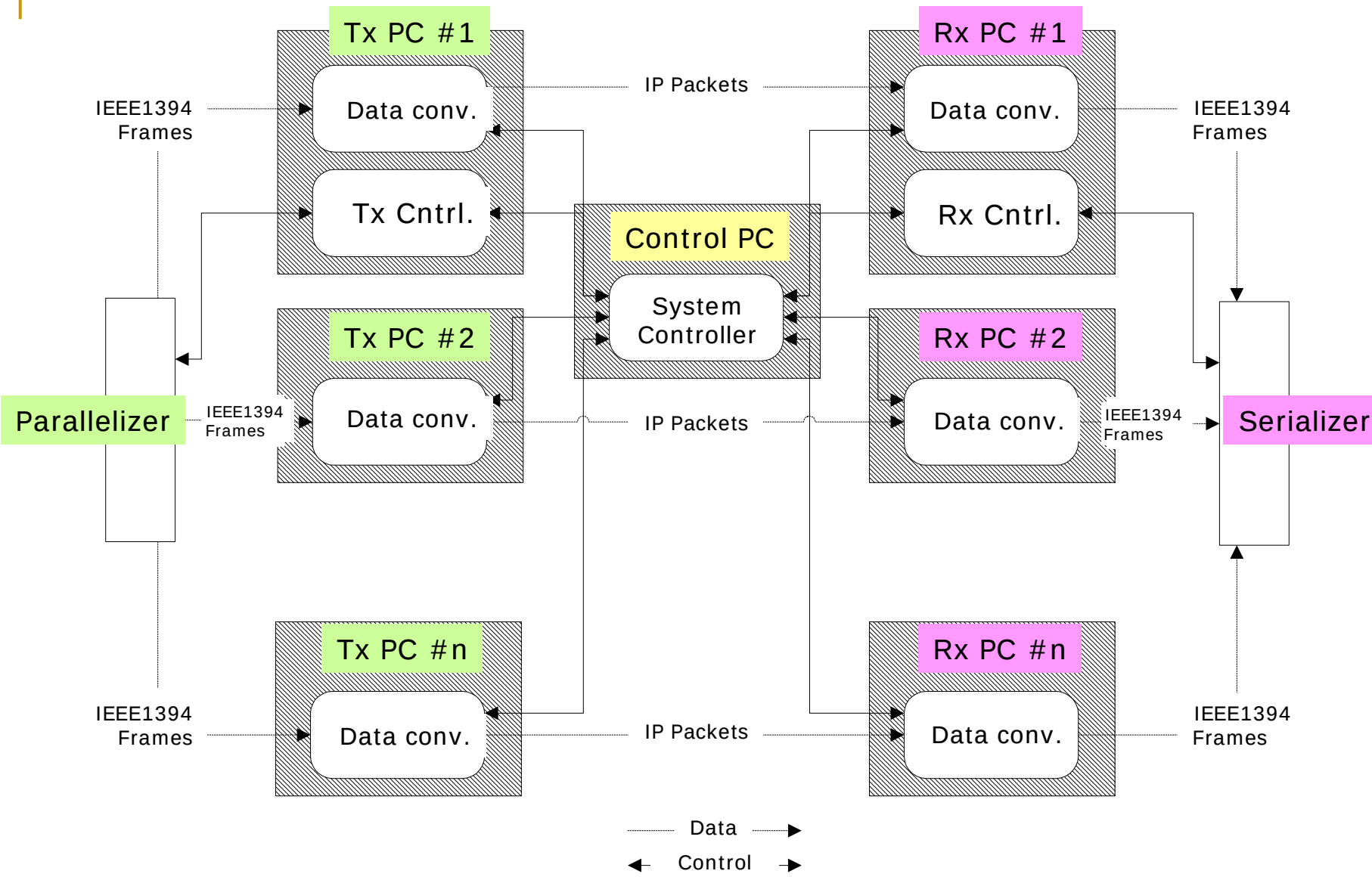
- IP-transmitting PC: IEEE1394 --> IP
- IP-receiving PC: IP --> IEEE1394
- Software: coded in C language
- UDP mode
  - UDP/IP with sequence number inserted in payload
  - packet loss detection by counting sequence number
  - packet loss control: dummy (random) data insertion at receiving PC keeping the original time slots
- TCP mode
  - Error control with TCP/IP
  - Realignment of data stream at receiving PCs
  - Batch mode/stream mode
- Platform (for both IP-transmitting and receiving)
  - Pentium 2/400
  - Linux 2.4.6

Serializer Unit

Specifications of Parallelizer / Serializer

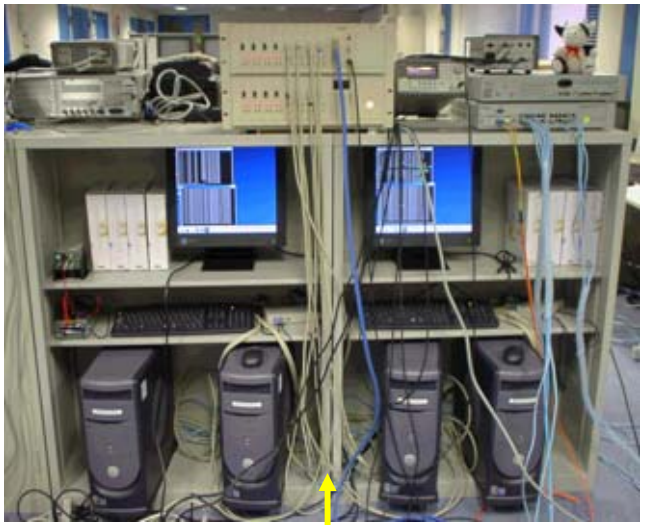
	ID1 parallelizer	ID1 serializer
Input I/F	ID1 x1	IEEE1394 x16
Output I/F	IEEE1394 x16	ID1 x1
Maximum PCs to connect	16	16
Internal data-block size (KB)	32, 64, 128, 256, 512, 1024 (manually selected)	←
ID1 clock (MHz)	Automatic synchronization to input ID1 I/F	2, 4, 8, 16, 32 (manually selected)
Maximum throughput (Mbps)	256	256

Software Modules



VLBI Data Transmission System

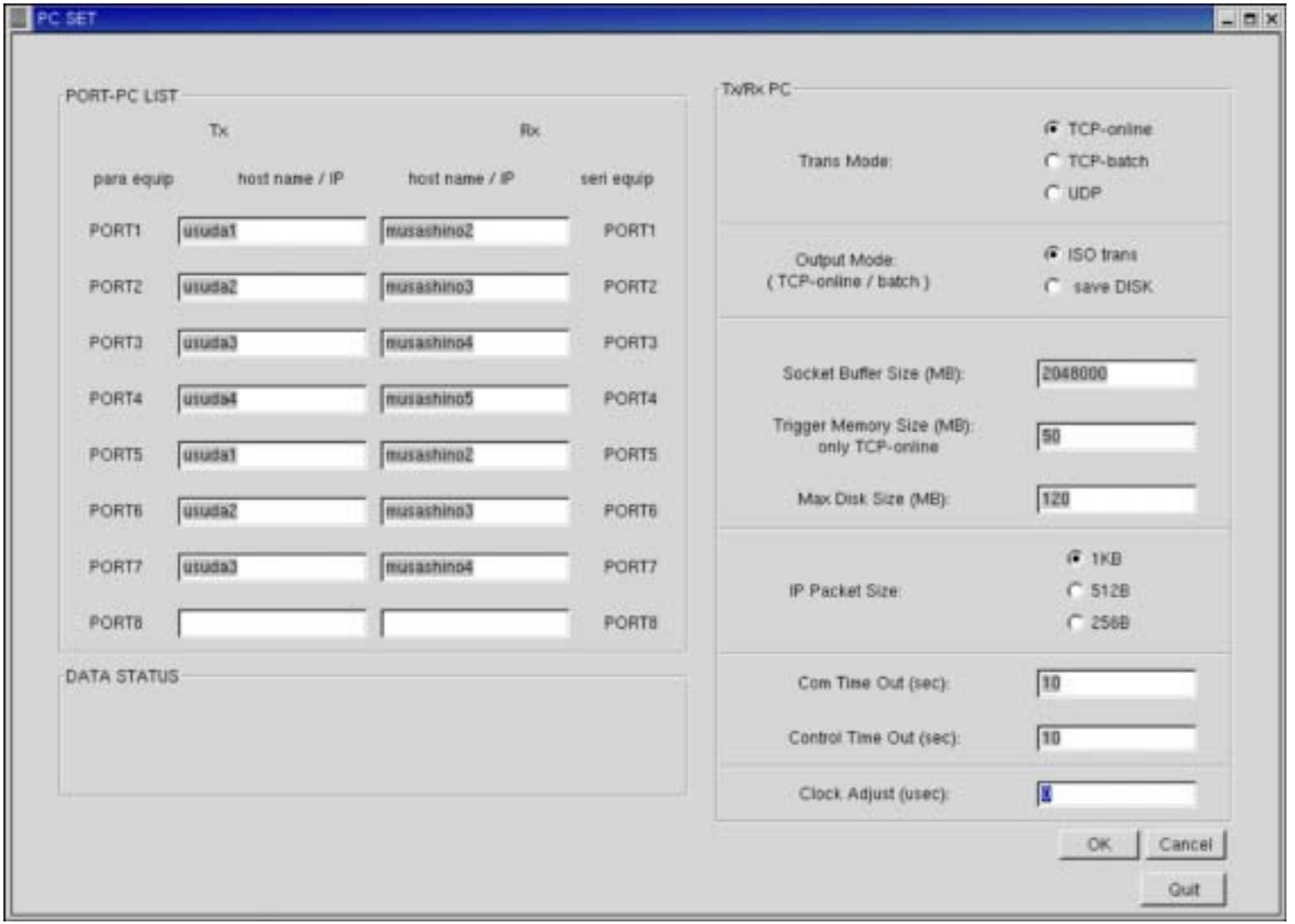
IP-transmitting PCs



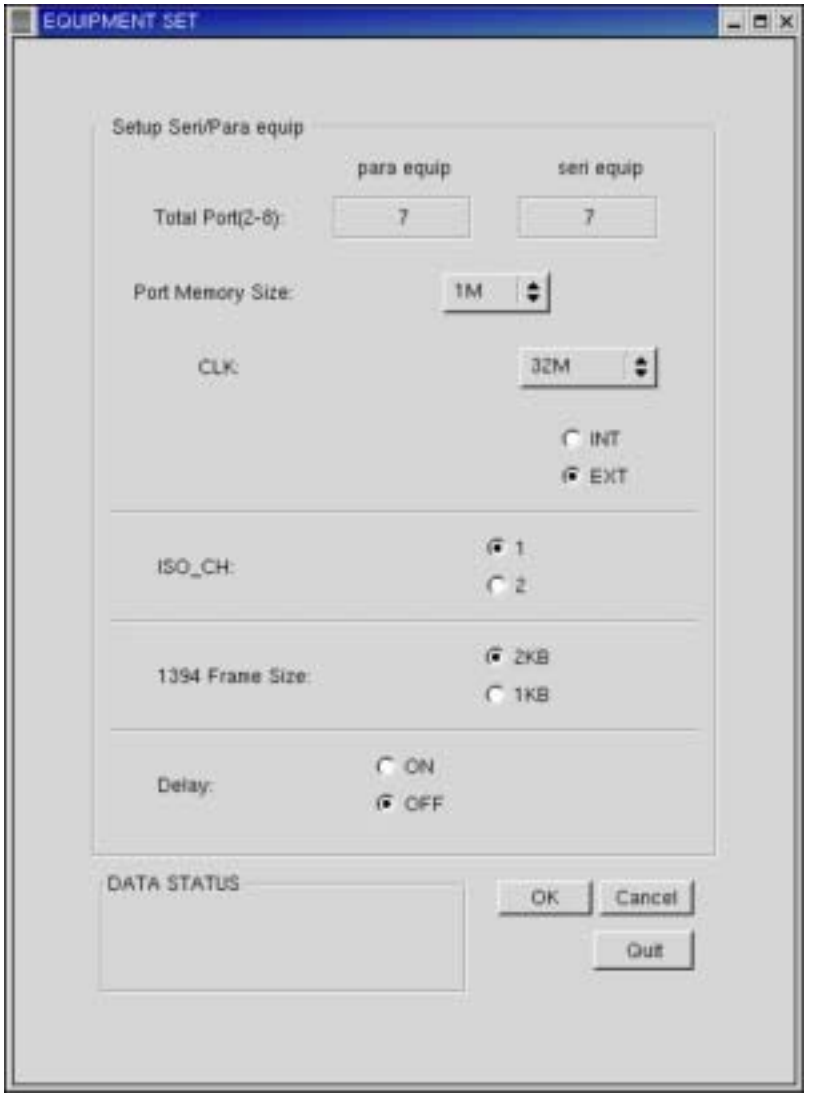
IP-receiving PCs and ID1 serializer

sampler and ID1 parallelizer

PC Setting Window



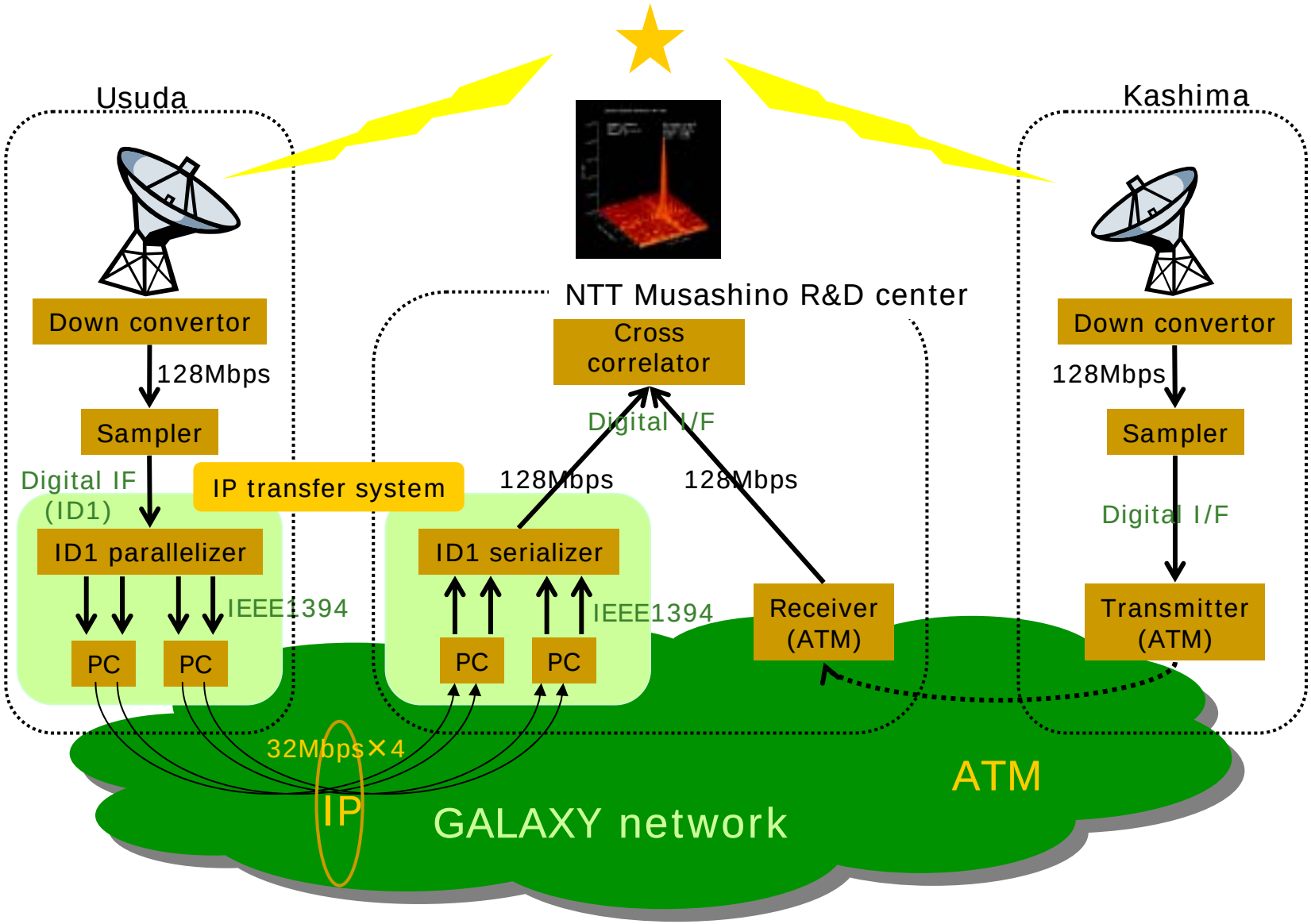
Hardware Control Window



System Control Window (TCP Batch Transfer Mode)

System Control Window (TCP Stream Mode)

Actual Observation using the system (Jan, 2002)



Future Plan

- Test under the real environment
  - Performance
  - Reliability
- Application to real observation
  - Observations with universities connected with Super-SINET in Japan
  - International observations over GEMnet and Abilene
- Speed upgrade
  - Development of VSI interface
  - Use of newer PCs with GbE interface
- Delay management
  - Automatic delay adjustment among channels
- Integration with software correlation

Acknowledgements

GALAXY members, CRL, Matsushita Electric Works, Ltd.

TCP Port Assignments