UltraScienceNet Research Testbed
Enabling Computational Genomics

Project Overview

John D. McCoy

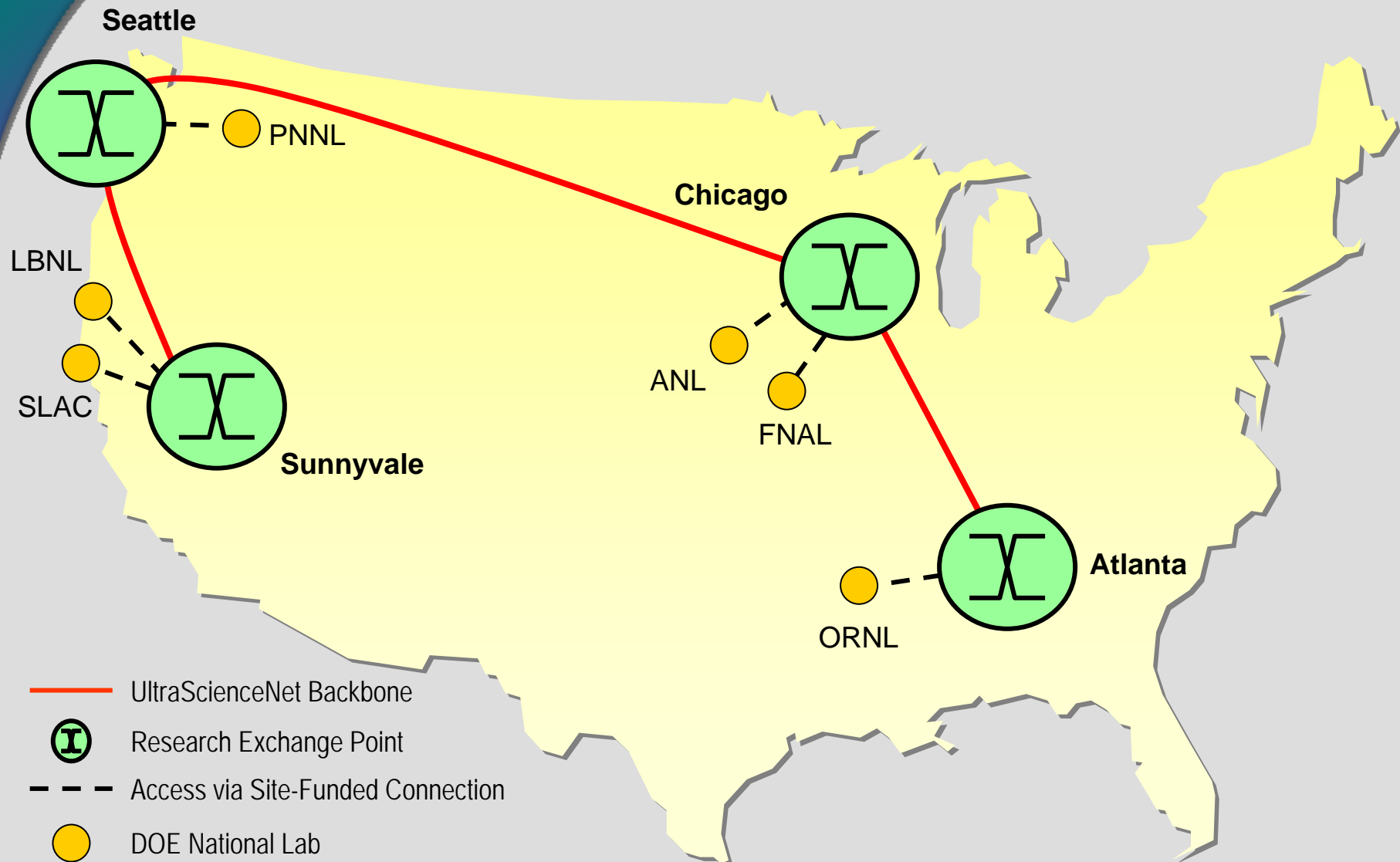Principal Investigator

Tom McKenna

Project Manager

Battelle

Pacific Northwest National Laboratory
Operated by Battelle for the
U.S. Department of Energy

Objective

▶ To research, design, and build a network research testbed over the DOE UltraScienceNet to enable computational genomic applications.

▶ This testbed will enable researchers to test and demonstrate applications that cause significant problems for traditional TCP/IP networks.

UltraScience Network

Seattle

PNNL

Chicago

LBNL

SLAC

Sunnyvale

ANL

FNAL

Atlanta

ORNL

UltraScienceNet Backbone

Research Exchange Point

Access via Site-Funded Connection

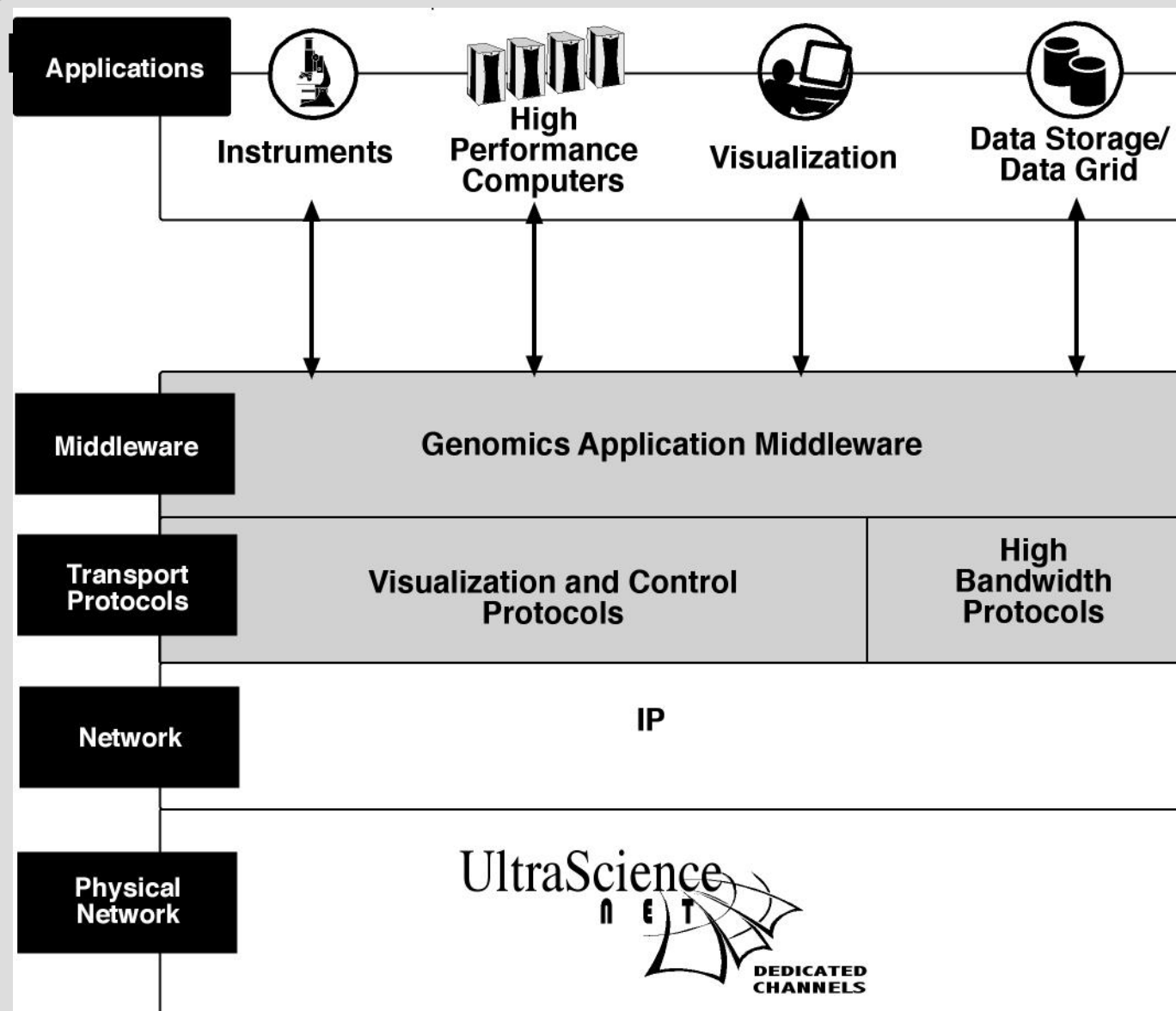DOE National Lab

Genomics Application Testbed
Research Focus

▶ Application drivers

- Cell biology using high-speed spectral confocal microscope
- Proteomics research using mass spectrometry

▶ Research focus

- Transport methods for remote instrument control
- High throughput protocols
- Visualization over dedicated channels

We will deliver a proof of concept

▶ Microscope prototype demonstration

- Exert remote control of high speed microscope in real time

- Near-real time visualization of the experiment

- Send high quality data to a network cluster for 3D rendering

- Store the high quality image for further analysis & replay

▶ Three Year Project – Design, Develop, Research

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Nikon Confocal Microscope

CaMatic

LaserCondition

Piezo ...

100 — 100
57.15
90 — 90
80 — 80
70 — 70
60 — 60
50 — 50
40 — 40
30 — 30
20 — 20
10 — 10
0 — 0
31.65

Steps 17
Step Size(uM) 1.5
Middle 44.4
100
Send
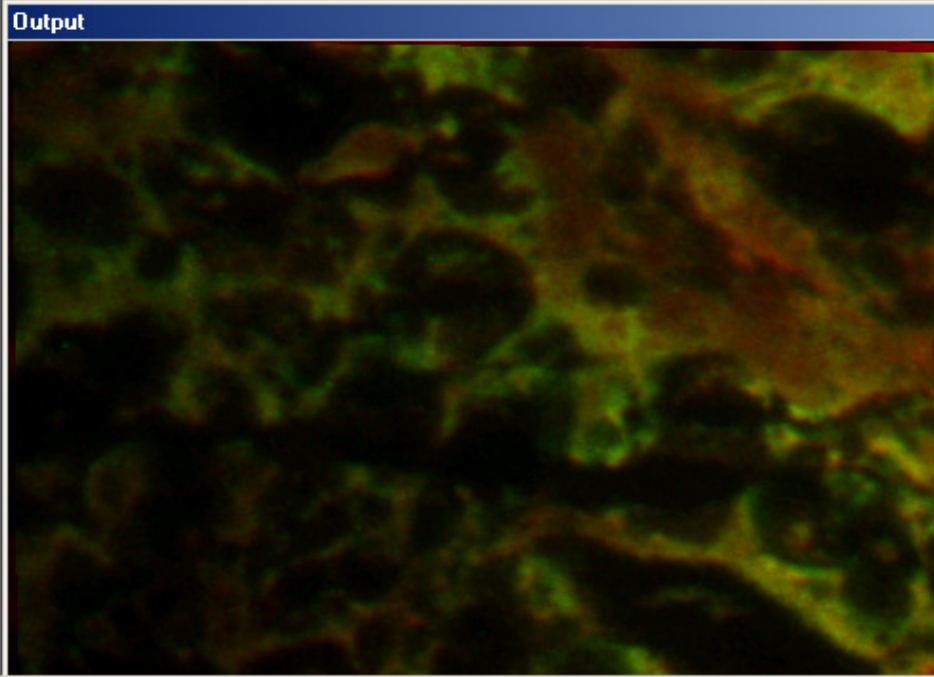
Camera

Output

Stage

Z Axis
1000
500
0
-500
-1000
-1000 -500 0 500 1000
100
50
0
-50
-100

	Target	Current Position		Voxel Calibation (um)
X	345.97	0	Move Relative	20X air-0.91
Y	317.65	0	Move Absolute	Go To Origin / Save Position
Z	0.00	0	Set Origin / Edit Positions	

FRET Control

Binning: None
Average: none

Trigger
☐ Save Data

Capture
○ None
○ Continuous
◉ Triggered

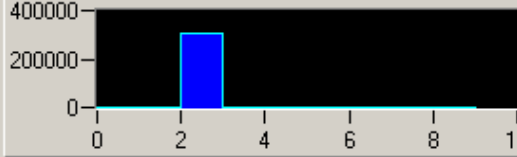Display
○ None
○ Preview
◉ FPGA
○ Calculated

Camera
◉ One
○ Two

Time Lapse
Steps 7
Time Delay (seconds) 1

400000
200000
0
0 2 4 6 8 1

Laser Control

647 nm 3.7 Send
568 nm 0 Send
530 nm 0 Send
520 nm 0 Send
514 nm 0 Send
488 nm 0 Send
476 nm 4.8 Send
457 nm 0 Send

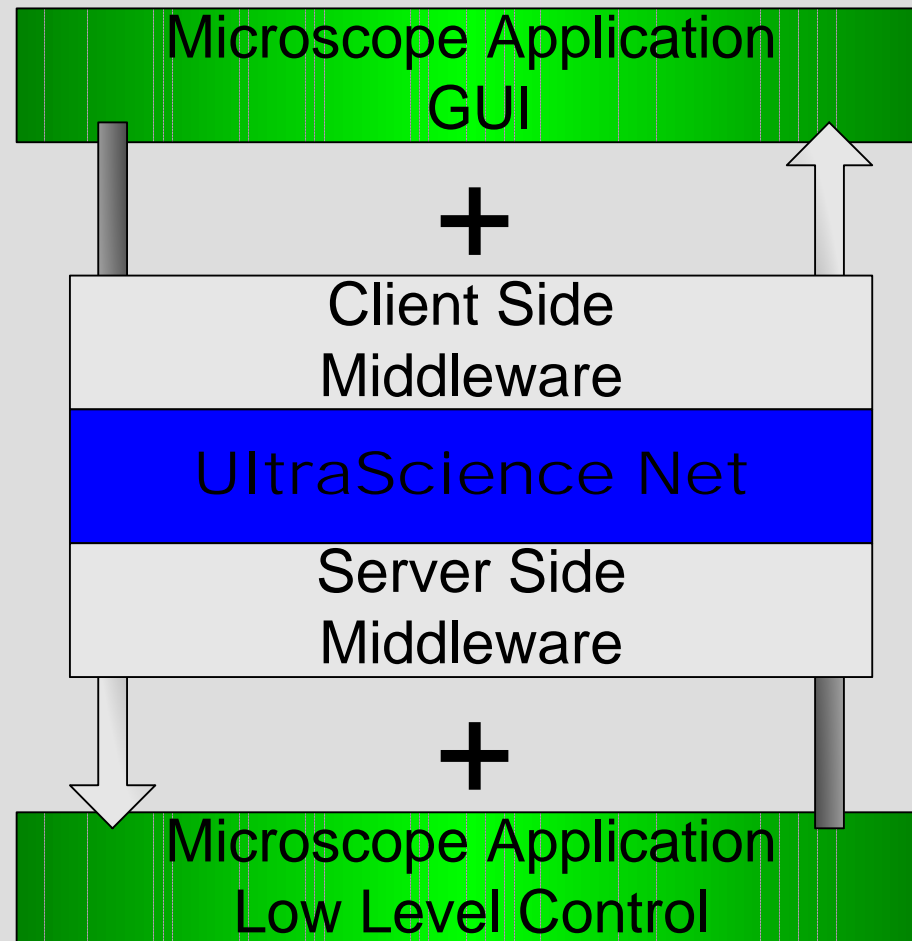## macro2 (macro) - Sax Basic [design]
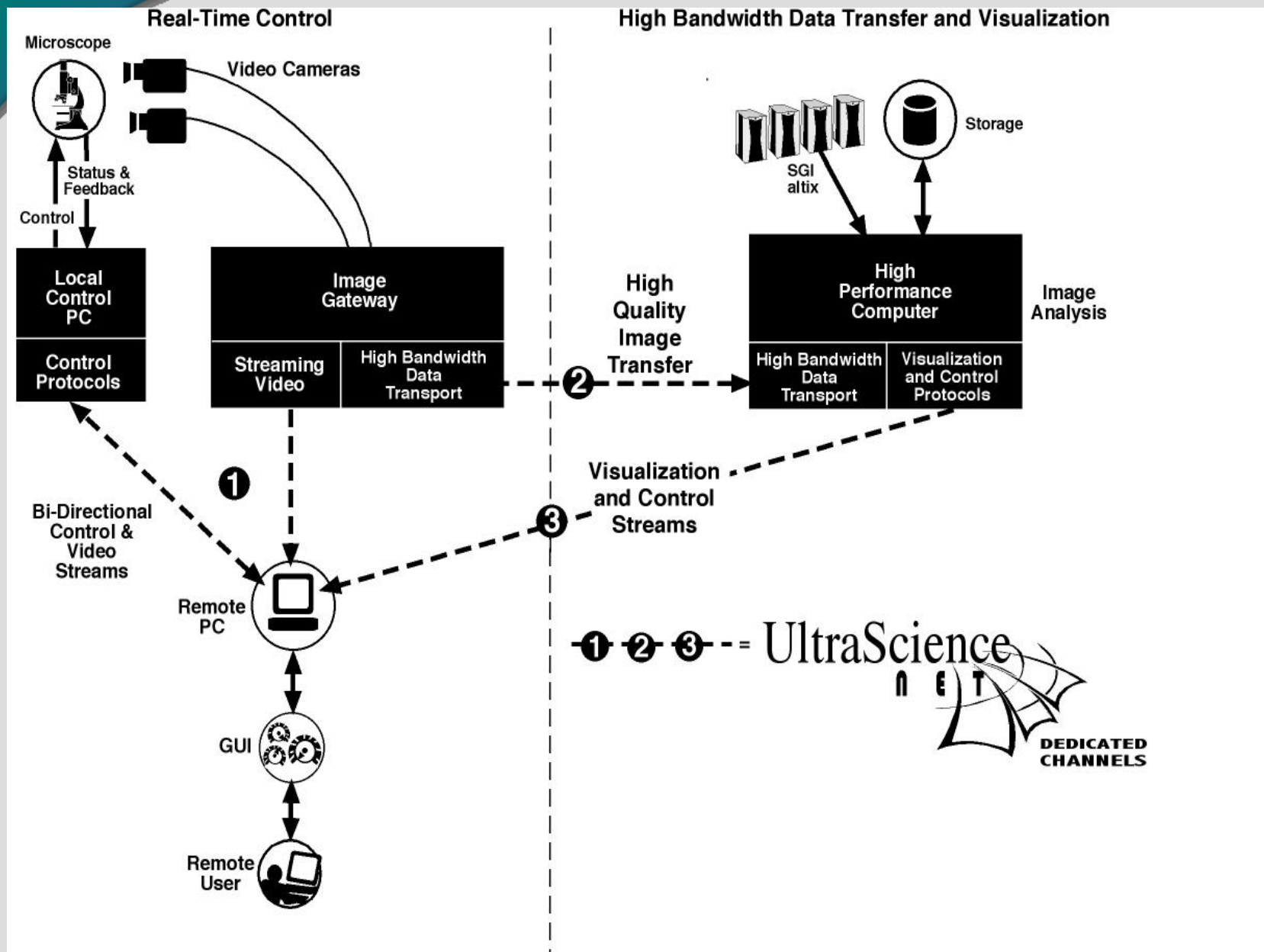
Proc: (declarations)

```
1    Option Explicit

     Sub Main
         Dim i As Long, j As Long, timeStampStep As Long, ti
```

Context Loaded

Stop All

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Issues / Design Considerations

► Real time data transfer

- Gbps speed

► Bulk Data Transfer

- Will be approaching petabyte sizes

► Data Availability

- Must be able to return image data quickly with high quality

► Remote Instrument Operation

- Need real time transfer of control signals
- No packet loss or delay jitter

► Remote Visualization

- Need near real-time access to visualizations of running experiments to gain collective insights into cellular responses, and to make immediate decisions regarding the future course of the experiment.

PNNL USN Research Partnerships
Growing the Program

► ORNL and Nagi Rao
- USN Connectivity, Visualization, Research Agenda

► Robert Grossman
- Univ. of Illinois - Chicago
- Incorporating UDT into network research testbed

► Scott Budge
- Utah State University
- FPGA and Streaming

► Richard Mount
- SLAC
- Bulk data management

Current Status

- Cross functional team of biologists, SW & HW developers, network engineers, graphics engineers is in place.
- Completed requirements specifications.
- Completed UltraScienceNet API
- Completed "remotizing" of confocal microscope application
- Completed microscope emulator
- Software Configuration Management system running
- USN Connectivity Completed
- Microscope Fiber Connectivity Completed.
- Current focus areas are on image capture and streaming
- Research agenda and collaborations ongoing.

Taking a Phased Approached Toward Enabling Network Research

▶ Phase 1 entails establishing the connectivity of the CaMatic software from a remote workstation to a server running software that emulates the confocal microscope over TCP/IP via the USN API. Currently working.

▶ Phase 2 includes streaming the real-time visualization imagery of the microscope via the USNAPI from the microscope to the remote workstation. Under Development.

▶ Phase 3 This will prove our ability to move large amounts of data off and on the machines utilizing 10GB network cards (Intel LR). Under Development.

▶ Phase 4 Test other protocols such as UDP and RTP - start executing research agenda. Year 3 of project.

Research Areas – In the Context of Genomics Need to Address:

► Storage, bus, and NIC optimizations

► Throughput vs speed

► Bandwidth allocation

► Latency (round trip response times)

► Remote sensing and instrumentation in a high speed, circuit switched network

► Logic for choosing control protocols

► Logic for choosing transport protocols

► Secure access rights to certain types of data - enable secure collaboration

► Cyber Security – IDS, IPS, Authentication, etc. Deployment and impact upon the biologist.

► Your input into research agenda is welcomed

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IMPACT

▶ The testbed will provide researchers and developers with an experimental infrastructure to provision on-demand, dedicated bandwidth to genomics applications.

▶ This work will facilitate genomic discovery by enabling scientists throughout the world to research, teach, and collaborate utilizing state of the art instruments.