Acronym soup

- University Corporation for Atmospheric Research (UCAR; http://www.ucar.edu)
- National Center for Atmospheric Research (NCAR)
- Front Range GigaPoP (FRGP)
- UCAR Point of Presence (UPoP)
- Bi-State Optical Network (BiSON)

- Local Area Networking (LAN), Metropolitan Area Networking (MAN), Wide Area Networking (WAN)
- Regional Optical Networks (RONs)
- International Networking

- Questions and discussions throughout please – and as for acronym soup ingredients, please ask if I miss one or check a decoder page at http://bit.ly/acronym-soup
Reviews and updates

- Front Range GigaPoP (FRGP)
- UCAR Point of Presence (UPoP)
  - Colorado K-12 networking
  - Colorado Telehealth Network (CTN)
- Bi-State Optical Networking (BiSON)
- National networking activities
  - WRN
  - Internet2
  - NLR
  - XSEDE
  - The Quilt, Inc.
  - Others/misc
FRGP

- Front Range GigaPoP
- 11 years of operation by UCAR Network Engineering and Telecommunications Section (NETS)
- 13 Members
- http://www.frgp.net
Front Range GigaPoP (FRGP)

- Increasing traffic
  - Level3, TeliaSonera (TSIC)
  - TransitRail (TR)/Commercial Peering Service (CPS)
  - Peering

- 8 members connected at 10Gbps
  - 1 planned

- DYNES with CU Boulder - pending hardware late 2011
FRGP members

- Colorado School of Mines
- Colorado State University System
- National Oceanic and Atmospheric Administration (NOAA-Boulder)
- State of Colorado
- United States Antarctic Program
- University Corporation for Atmospheric Research
- University NAVSTAR Consortium (UNAVCO)
- University of Colorado Boulder
- University of Colorado Colorado Springs
- University of Colorado Denver
- University of Denver
- University of Northern Colorado
- University of Wyoming
Western Regional Network (WRN): a multi-state partnership to ensure robust, advanced, high-speed networking availability for research, education, and related uses through the sharing of network services

Expansion and sharing of network services in support of advanced research and operations

Support of academic, economic development, and inter-regional services
WRN members

- Pacific Northwest GigaPop (PNWGP)
- Front Range GigaPoP (FRGP)
- The University of New Mexico (on behalf of the State of New Mexico)
- Corporation for Education Network Initiatives in California (CENIC)
- University of Hawaii – pending
- http://westernregional.net/
Increased potential for shared applications among communities across the west—networking services to the following states:

- Alaska
- California
- Colorado
- Hawaii
- Idaho
- Montana
- Nevada
- New Mexico
- Washington
- Oregon
- Wyoming
WRN for FRGP

- Intra-region peering
- NLR and Internet2 services shared and backed-up
- Back each other up (provide diverse layer 2 and 3 to cover on-net failures)
- Efficient and cost-effective TR/CPS
- Potential place to land for-profits from CTN, EAGLE-Net, US-UCAN, others?
UPoP

- UCAR Point of Presence
- http://upop.ucar.edu
- 4 years of operation
- 21 members
UPoP members

- ARTstor
- Auraria Higher Education Center
- Colorado Association of Research Libraries
- City of Boulder
- City and County of Denver
- Colorado Community College System
- Colorado Telehealth Network
- Community College of Denver
- Colorado Department of Higher Education
- Colorado Mountain College
- Denver Health and Hospital Authority
- DIA
- EAGLE-Net
- EDUCAUSE
UPoP members

- Fort Lewis College
- Front Range Internet, Inc. (two school districts)
- Metropolitan State College of Denver
- Open Media Foundation
- St. Mary's Academy
- Science and Technology in Atmospheric Research (STAR) Institute
- University of Colorado Hospital
UPoP – future connections

- Additional school districts
- WICHE - [http://www.wiche.edu/](http://www.wiche.edu/)
- PacketRail [http://www.packetrail.net](http://www.packetrail.net) connections (e.g., FLC)
- Frequent discussions with a variety of others
Colorado Telehealth Network

- FCC Rural Health Care Pilot Program (RHCPP)
- Colorado Health Care Connections (CHCC; from Colorado Hospital Association (CHA))
- Rocky Mountain Healthcare Network (RMHN; from Colorado Behavioral Healthcare Council (CBHC))
- CTN has FCC RHCPP funding
- Qwest actively operating network since 6/11
- http://www.cotelehealth.com
- Internet2 Health Network Initiative:
  - http://www.internet2.edu/health/
- NLR: http://www.nlr.net
EAGLE-Net

- Educational Access Gateway Learning Environment Network
  - [http://www.co-eaglenet.net/](http://www.co-eaglenet.net/)

- BTOP round 2 award received

- Intergovernmental Agency (IGA)
  - Rolled out from CBOCES
  - Board in place
  - Technical Advisory Committee being formed

- Environmental Assessments received summer 2011

- RFI on the street for fiber opportunities

- Connect all school districts (178) in Colorado
SEGP updates

- Intended to allow expanded access to the Internet2 network for regional education networks through sponsorship by Internet2 university members.
- State and regional networks connect K-20 educational institutions.
- The program began in early 2001 and as of June 2011 there are 39 SEGPs.
- Colorado SEGPs provide Internet2 services to all qualified FRGP and UPoP members and costs shared.
BiSON partnership

- Bi-State Optical Network (BiSON)
- 5 year old partnership between NCAR, NOAA-Boulder, University of Wyoming, University of Colorado and Colorado State University
- Goal: create an optical WDM network connecting Denver, Boulder, Longmont, Fort Collins, and Laramie
BiSON future plans

- Expand dark fiber plant to include NCAR Wyoming Supercomputing Center (NWSC)
- Initially at least four 10G circuits will be active
- Expansion to 40G and 100G capability
- Direct connections for High Performance Computing to other BiSON members also an option
NWSC WAN
Conceptual Diagram

- NCAR Internal to ML
- FRGP / Internet / R&E
- Optional UW Dedicated

All links are 10G Ethernet carried via BiSON DWDM.
BiSON Capacity

- System is engineered for 40 individual lambdas
- Each lambda can be a 10G, 40G, or soon a 100G connection
- Independent lambdas can be sent each direction around the ring
- With a major upgrade system could support 80 lambdas
- $100\text{Gbps} \times 80 \text{ channels} \times 2 \text{ paths} = 16\text{Tbps}$
NWSC

- NCAR Wyoming Supercomputing Center
  - [http://www.cisl.ucar.edu/nwsc](http://www.cisl.ucar.edu/nwsc)

- Scheduled to be occupied in October 2011
  - Certificate of Occupancy

- Supers RFP out – pending NSF approval - system delivered 12/11 and open to users 3/12

- NWSC datacenter switch/router RFP out – pending NSF approval

- BiSON fiber connectivity in progress – north leg in place and active – south leg due by 11/1/11
Internet2

- US UCAN in progress
  - Connect Community Anchor Institutions (CAIs)
  - 100Gbps upgrade to I2 network

- [http://www.internet2.edu](http://www.internet2.edu)
National Lambda Rail (NLR)

- [http://www.nlr.net](http://www.nlr.net)
- Purchased by National Coalition for Health Integration
- Class A members now Class B members
- NLR network upgrade to 100Gbps in planning stage
- Class members control half the capacity - currently 20 north/16 south 10Gbps lambdas
NOAA-WAVE (N-WAVE)

- NOAA building national NOAA research network called N-WAVE
- Utilizing I2 and NLR 10Gbps lambdas
- Initial sites: NOAA-Boulder, NOAA-DC, GFDL, ORNL
  - Complete
- Secondary sites: Seattle, Florida, Oklahoma
  - In-progress
- Used ARRA funds
ESNet


- ARRA Advanced Networking Initiative (~$62M)

- 100G Prototype Network and Testbed

- DOE scientists are now generating data at the terabyte scale, and datasets will soon be in the petabyte range

- LHC: also a very large networking experiment

- Network will be constructed on I2/Level3 infrastructure
XSEDE

- NSF funded
- XSEDE is a single virtual system that scientists can use to interactively share computing resources, data and expertise. People around the world use these resources and services — things like supercomputers, collections of data and new tools — to improve our planet.
- 10Gbps network
- Follow-on to Teragrid
- https://www.xsede.org/
The Quilt, Inc.

- [http://www.thequilt.net](http://www.thequilt.net)
- 28 members currently:
  - [http://www.thequilt.net/participants.html](http://www.thequilt.net/participants.html)
- Non-profit regional network aggregators providing advanced network services in support of research and education
- Several work groups, lots of tracking, coordination and strategic planning efforts
- FRGP no longer purchases off the Quilt CIS program
  - Canceled Qwest 9/30/11
  - Purchase TeliaSonera via NLR - b/w counts toward Quilt CIS and NLR/TSIC is an AQP
  - Purchase Level3 via WRN - b/w counts toward Quilt CIS
Drivers for 100 Gbps Services

- Need for Massive Additional Capacity
  - Support for Capacity Much Beyond Aggregation of Millions of Small Flows
  - Support for Extremely Large Individual Stream (Including End-To-End)

- Communications for Data Intensive (e.g., Petascale Science)

- Communications for Specialized Highly Distributed Environments

- Environments Directly Controlled By Edge Processes (Application Specific Network Services)

- Highly Controllable Science Workflows

- Begin Migration From Centralized NOCs

- Science Clouds (vs Consumer and Enterprise)

- Many New Applications and Services That Cannot Be Supported Today
Four Worlds of 100 Gbps

- 100 Gbps Routing
- 100 Gbps Ethernet
- 100 Gbps Optical
- Other... e.g., Fiber Bundles, Interconnections, Control Planes, etc.
100 Gbps Services: Routing

* 100 Gbps Routing
  - Available Today Based on Proprietary Technology
  - Optimal Network Designs Place Such Devices At the Network Edge vs Network Core
100 Gbps Services

- 100 GigE L2 Switching

- Standard: IEEE 802.3ba
- Technical changes Finalized In July 2009
- Formal Final Approval Took Place In July 2010
- Beta Products Available Q4 2010
- 1st Commercial Products End of Q4 2011
- Provides for a Rate of 103.125 Gbps
100 Gbps Services: WAN Side/Line Side

100 Gbps Optical Switching

- Standard: ITU G.709 v3 (ODU4 100G)
- ODU4/OTU4 Format -- Designed to Transport 100GbE (OTU4 = the ODU4 With FEC Included)
- Formal Final Approval Took Place In Dec 2009
- Beta Products Available Today
- Ref: Demonstrations at SC10
- 1st Commercial Products Available End of Q3 2011
End to End Networking

- Multiple aspects of end-to-end flows:
  - Host performance, e.g. buffers, bandwidth delay product, packet size
  - Protocol and transfer methods performance, e.g. GridFTP, TCP, etc.
  - Application performance
  - Slowest link in path limiting factor
  - Collaborate with remote network teams and system administrators, and wide-area network (WAN) service providers to identify and remove bottlenecks along the network path, and improve your flow throughput, e.g. routers, switches, asymmetric routing
  - Use proactive and reactive tools, e.g. Perfsonar, iperf
Discussion

• Any follow up questions or feedback on items covered?
• Other items?

Thank you!