casa Engineering Research Center for
Collaborative Adaptive Sensing of the Atmosphere

Radar Networking in Collaborative Adaptive Sensing of the Atmosphere (CASA):

State of the Art & Research Challenges

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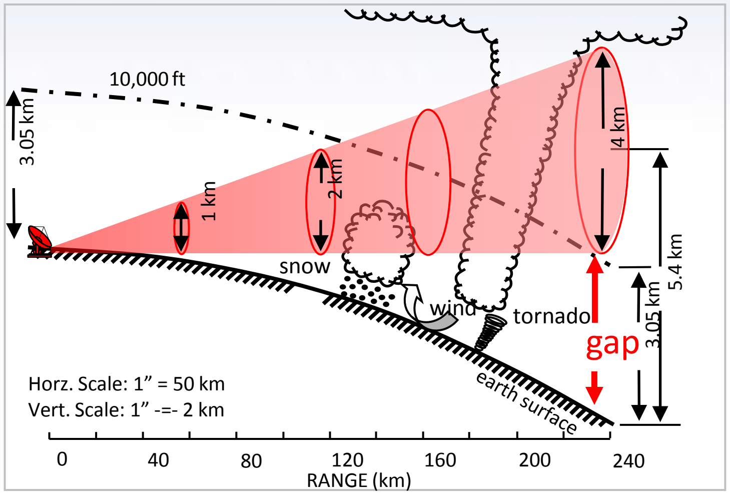
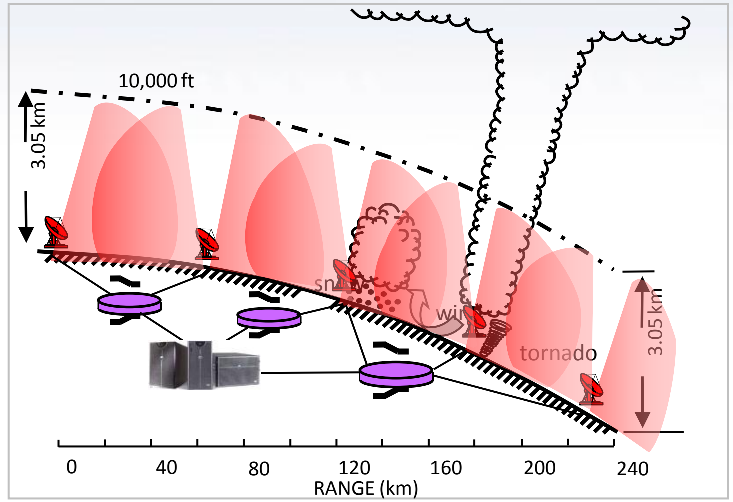
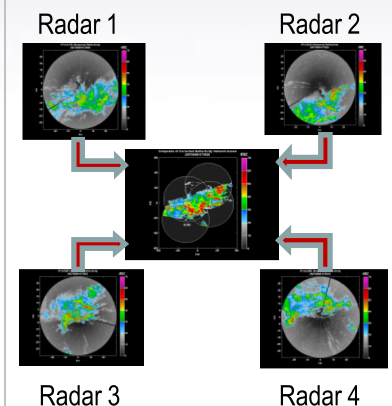
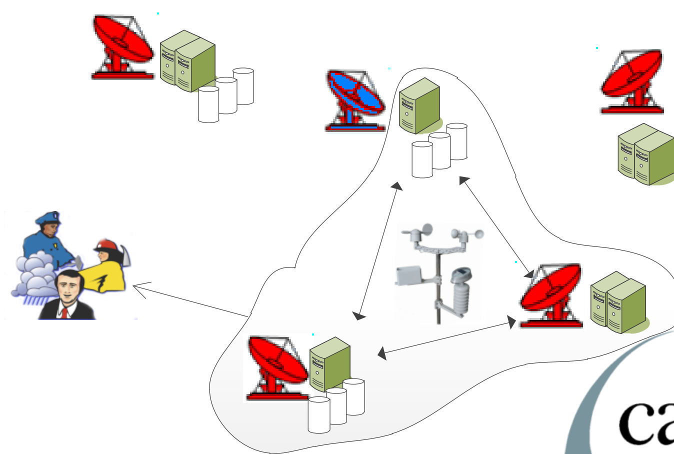
Collaborative Adaptive Sensing of the Atmosphere (CASA)



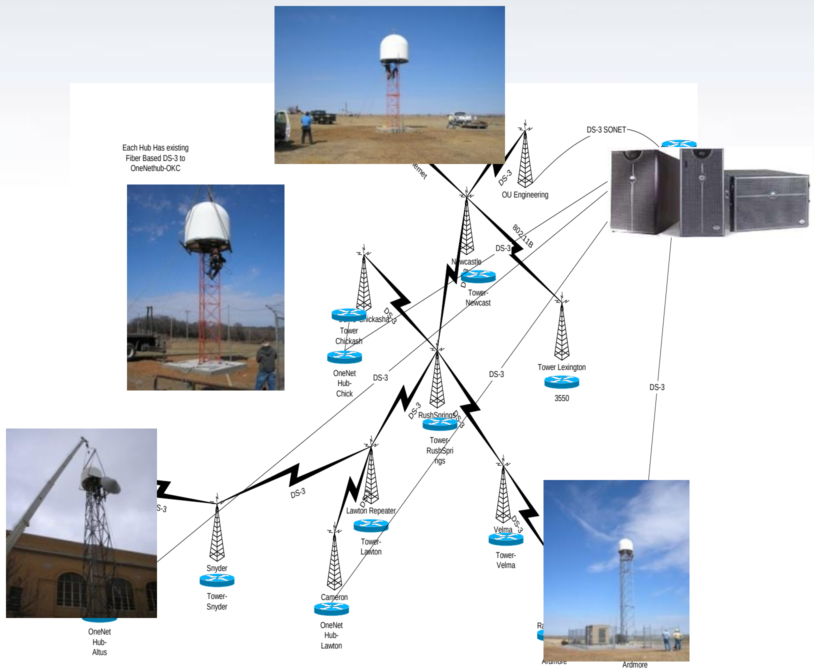


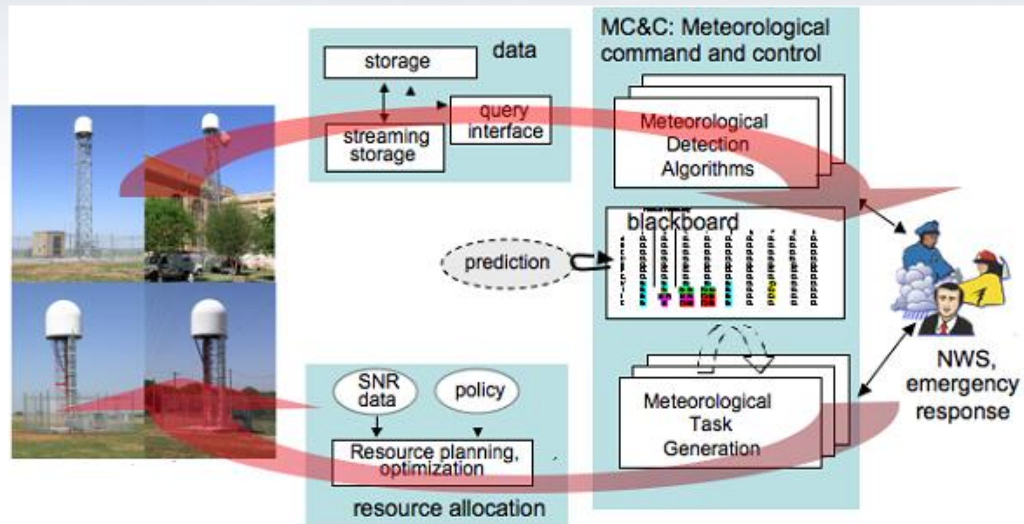


- Collaborating & adapting radars
  - Improved sensing, detection, & forecasting
- Aggregates distributed groups of resources as & when needed
  - 10,000 radars to cover U.S.
  - High data rate – 800 Mbps
  - Heterogeneous, dynamic, & distributed
  - Real-time – 30 sec heart beat

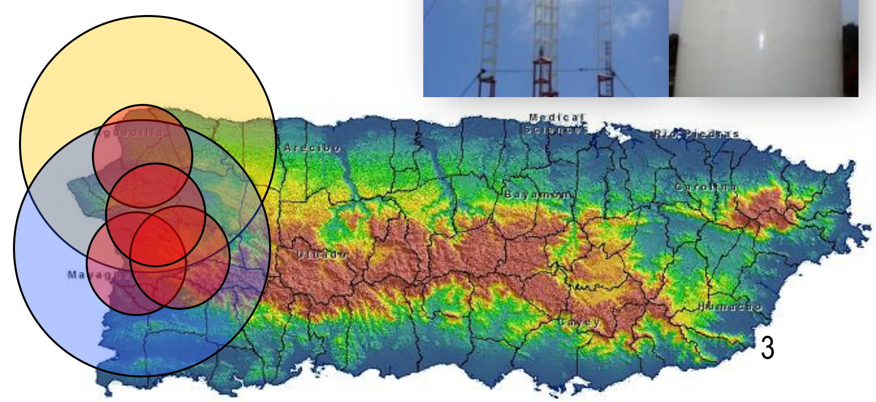


CASA Test Beds





- Oklahoma test bed
  - 7,000 km^2 , 40 km range, 30 km spacing
  - Connected to the Internet
  - Data pull – 30 sec heart beat
  - Being moved to Dallas-Fort Worth
- Puerto Rico student test bed
  - Solar powered
  - Wireless connections



CASA Applications & End Users

Application	Description	No of Radars	Data Type(s)
Reflectivity	Reflectivity of clouds	1	Reflectivity
Velocity	Wind velocity	2-3	Doppler velocity, reflectivity
Network-Based Reflectivity Retrieval (NBRR)	Reflectivity of clouds detected using multiple radars	3+	Reflectivity
Nowcasting	Short term (10-30 min) high resolution forecasts of active weather events	1-3	Reflectivity
Tornado tracking	Detect & track a tornado as it forms & moves	2+	Doppler velocity, reflectivity

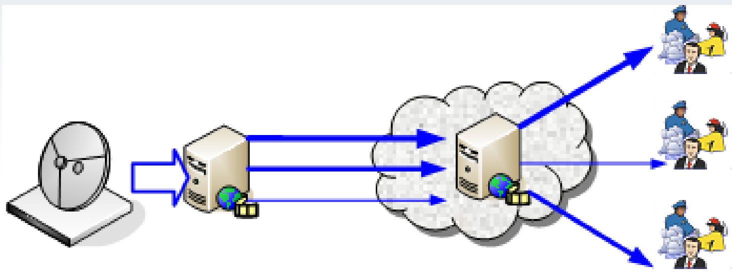
End user	Description	Applications	Rule Trigger	AOI	Sampling Interval
National Weather Service (NWS)	Responsible for issuing warnings	Reflectivity	Periodic	Counties under jurisdiction	1 min
		Velocity			
		NBRR, nowcasting, QPE	High reflectivity	Area of active weather	
		Tornado tracking	Rotating wind, ground spotters		
Emergency Managers (EMs)	Siren blowing, helping first responders, act as spotters	Reflectivity	Periodic	Counties under jurisdiction	1 min
		Velocity			
		NBRR, nowcasting, QPE	High reflectivity	Area of active weather	2 min
		Tornado tracking	Rotating wind, ground spotters		1 min
Researchers	To understand physical properties of weather events, test new algorithms	Reflectivity	Periodic	Area of active weather	1 min
		Velocity	High wind		30 sec
		NBRR, nowcasting, QPE	High reflectivity		1 min
		Tornado tracking	Rotating wind		30 sec

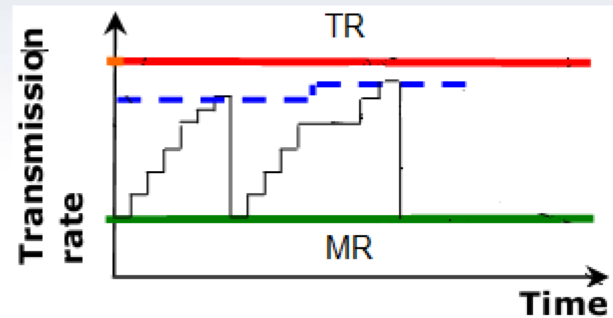
- Same data accessed by multiple applications & end users

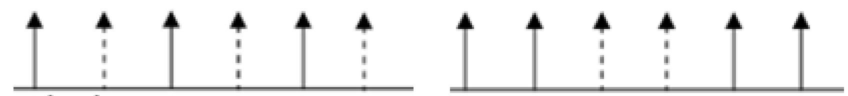
Data Transfer & Fusion

- Data Transfer & Data Fusion
  - Streaming
    - TRABOL – End-to-end
    - AWON – Multicasting
    - Modeling data fusion latency
    - Integrating Other Sensors
  - Pull
    - Sensor-specific names
      - Proxy-based
      - P2P-based
      - Data Intensive Clouds
    - Data-specific names
      - NDN-based
  - Archive

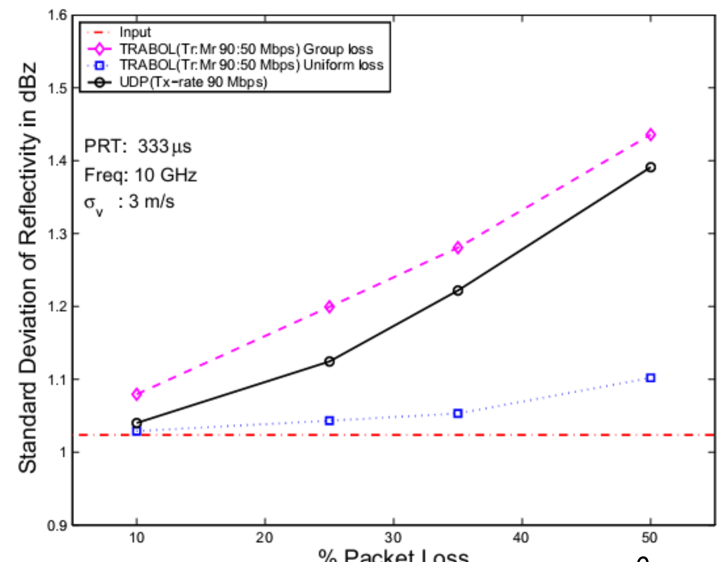
Streaming – TCP friendly Rate Adaptation Based On Loss (TRABOL)





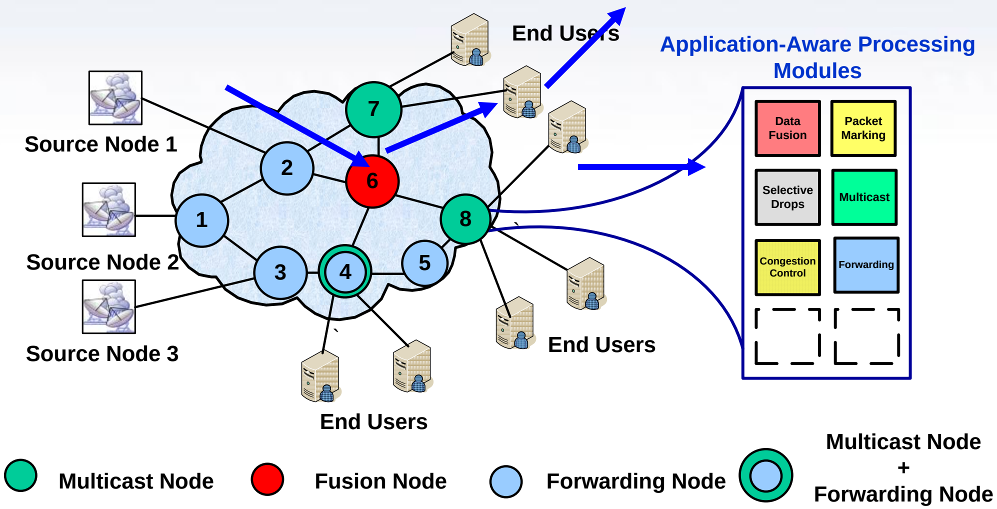


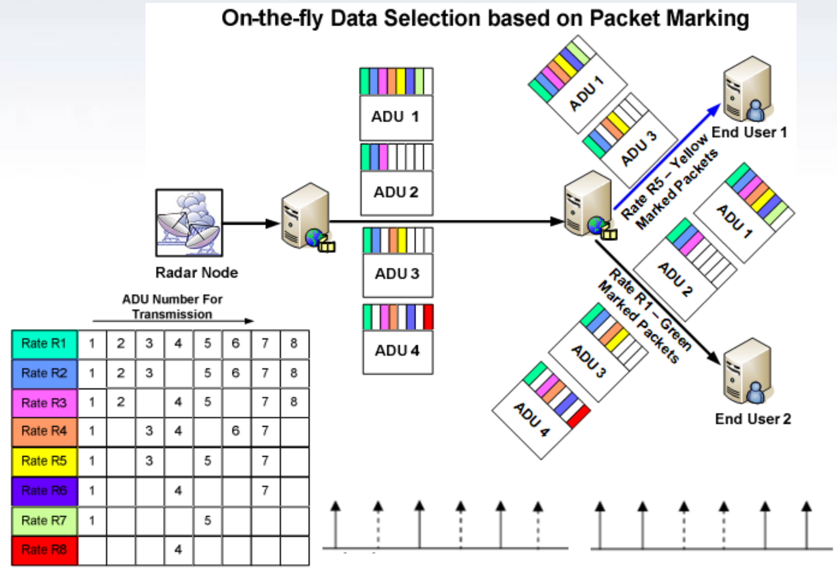
- Target Rate (TR)
  - Users prefer to receive all relevant data
- Minimum Rate (MR)
  - Most important data
- TCP & UDP inadequate
- TRABOL
  - Application-layer solution
  - Application-aware packet drop
  - Enhance quality of received data



T. Banka et al., "Radar networking: Considerations for data transfer protocols and network characteristics," 21st Int. Conf. on IIPS for Meteorology, Oceanography, and Hydrology, Jan. 2005.

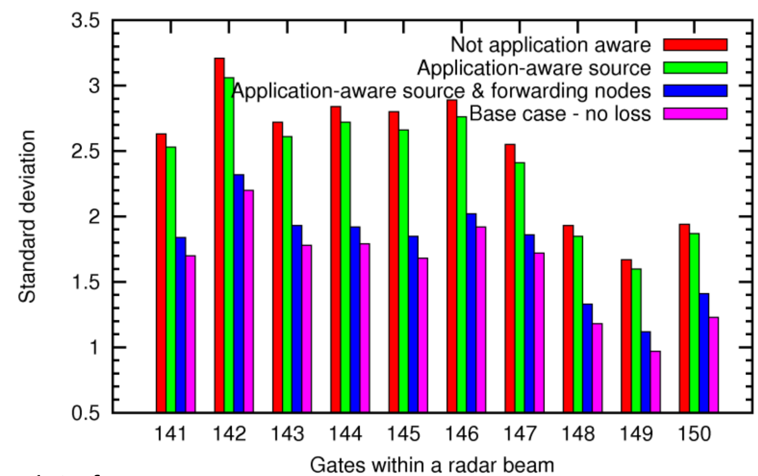
Multicasting – Application-Aware Overlay Networks (AWON)





Rate R1	1	2	3	4	5	6	7	8
Rate R2	1	2	3		5	6	7	8
Rate R3	1	2		4	5		7	8
Rate R4	1		3	4		6	7	
Rate R5	1		3		5		7	
Rate R6	1			4			7	
Rate R7	1				5			
Rate R8				4				

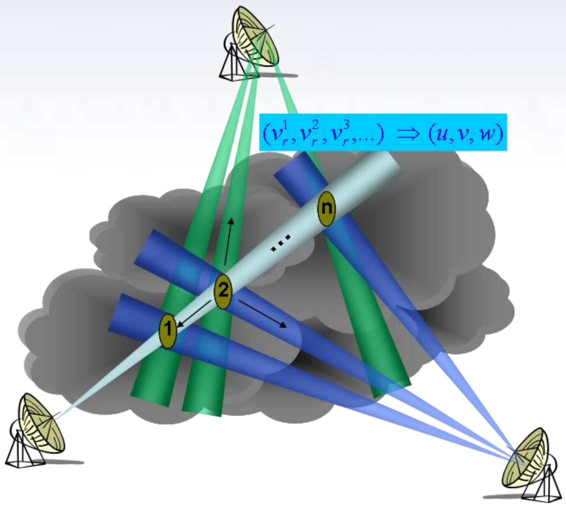
- API for application-aware service deployment
- Application-aware
  - Packet marking
  - Data delivery under varying network conditions

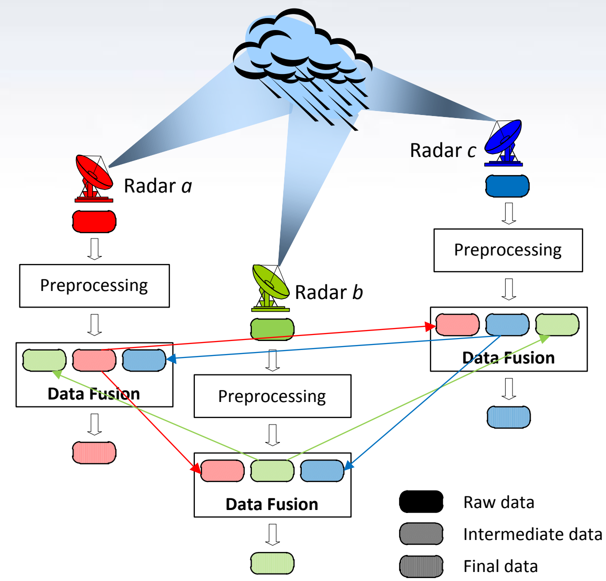


T. Banka, P. Lee, A.P. Jayasumana, & J. F. Kurose, "An architecture and a programming interface for application-aware data dissemination using overlay networks," COMSWARE '07, Jan. 2007.

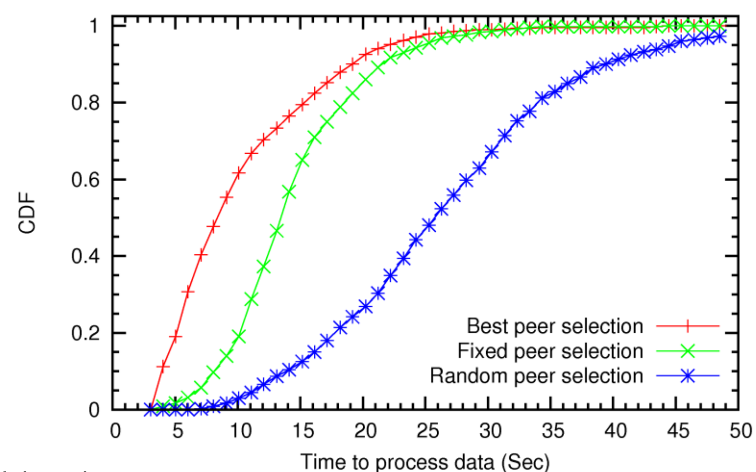
Measurements on PlanetLab
60% reduction in link capacity

Data Fusion – Peer-to-Peer Collaboration Framework





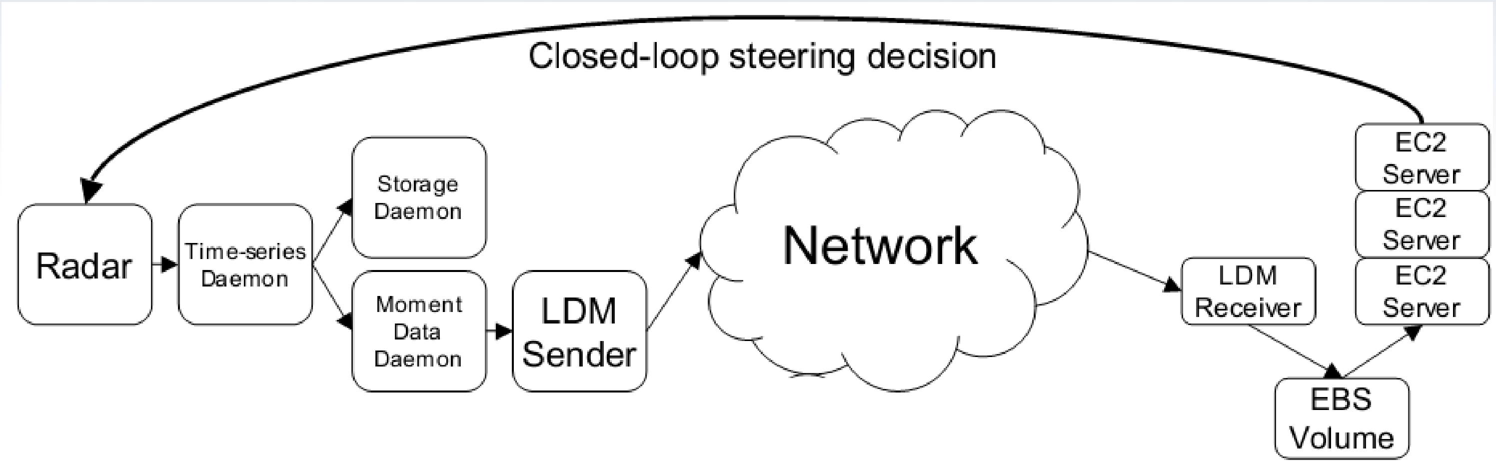
- Radars depend on each other's data to correct/detect errors
  - Subscribe to neighbors
- Best peer selection
  - Peers with relevant data
  - Peers with lowest data delivery time
    - Computation + transmission



40% cross traffic

P. Lee, A.P. Jayasumana, H.M.N.D. Bandara, S. Lim, & V. Chandrasekar, "A peer-to-peer collaboration framework for multi-sensor data fusion," Journal of Network & Computer Applications, May 2012.

Data Fusion – Data Intensive (DI) Clouds

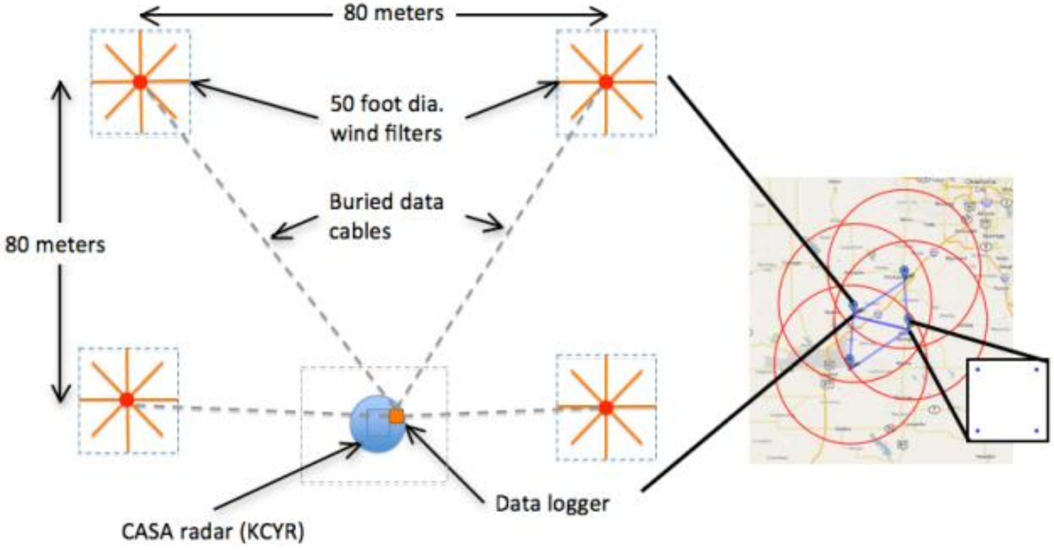


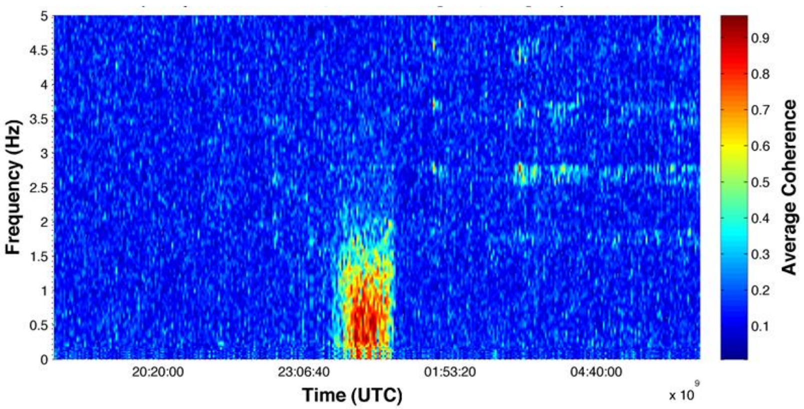
- Infrequent peak demands
- Cloud computing is a good fit
- Enable data-intensive experiments/ workflows from start to finish
  - Radars, weather stations, & cameras
    - Virtualized access to sensors
    - Developed under GENI ViSE project
  - Processing & storing in Amazon cloud

Data Intensive Cloud Control, http://geni.cs.umass.edu/vise/dicloud.php

Data Fusion – Integrating Infrasound Sensors

- Tornados & their precursors produce infrasound (< 20 Hz)
- Increase accuracy of detection, warning time, & localization





May 22, 2011 at Cyril site

D. Pepyne & S. Klaiber, "Highlights from the 2011 CASA Infrasound field experiment," 92nd American Meteorological Society Annual Meeting, Jan. 2012

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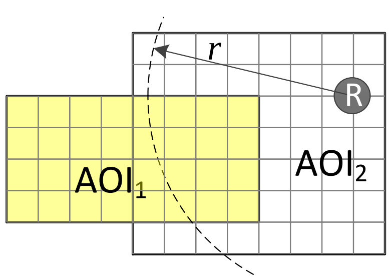
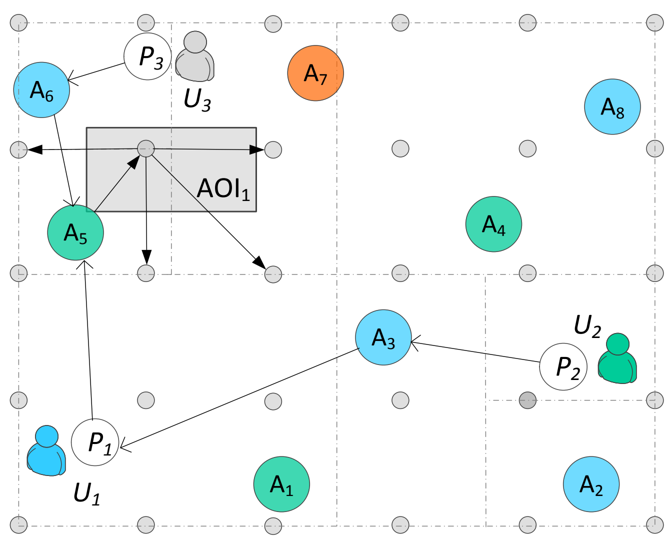
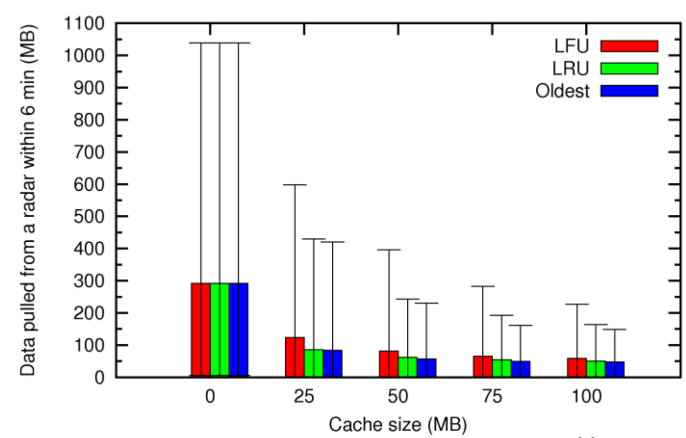
Multi-User, Multi-Application, & Multi-Sensor Data Fusion Over Named Data Networks (NDN)

Geographic location & weather event specific names	Content dependent names •/Anaheim/Reflectivity/10:30/
Decouple data, security, & access from sensor	Decouple identity, security, & access from end point
Load balancing, resilience, & security	Better reliability & security
Pull based • Users determine how resources are used	Receiver driven communication • On demand data generation
High temporal & spatial locality	Exploit temporal & spatial locality



/AOI/application/time





Research Opportunities & Challenges

- Integrating diverse sensors
  - CASA, solid state, long-range, special purpose, & mobile radars
  - Micro weather stations, pressure sensors, wind profilers, etc.
  - How to transfer & process?
    - Different data types, generation patterns, processing, & bandwidth requirements
- Aggregating distributed groups of resources
  - As & when needed
  - Heterogeneous, distributed, dynamic, & multi-attribute resources
  - Real time & distributed resource matching, binding, & compensation
- Data intensive clouds
  - Transferring data in/out of clouds
    - On demand virtual networks across ISPs
  - Rapid resource deployment
  - Cloud-based processing strategies for weather data
    - Models to understand performance & cost benefits

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Questions/Comments

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