



WildfireDLN



Wildland Fire Data Logistics Network (WildfireDLN) *A Demonstration of Resilient Data Sharing*

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DISCLAIMER

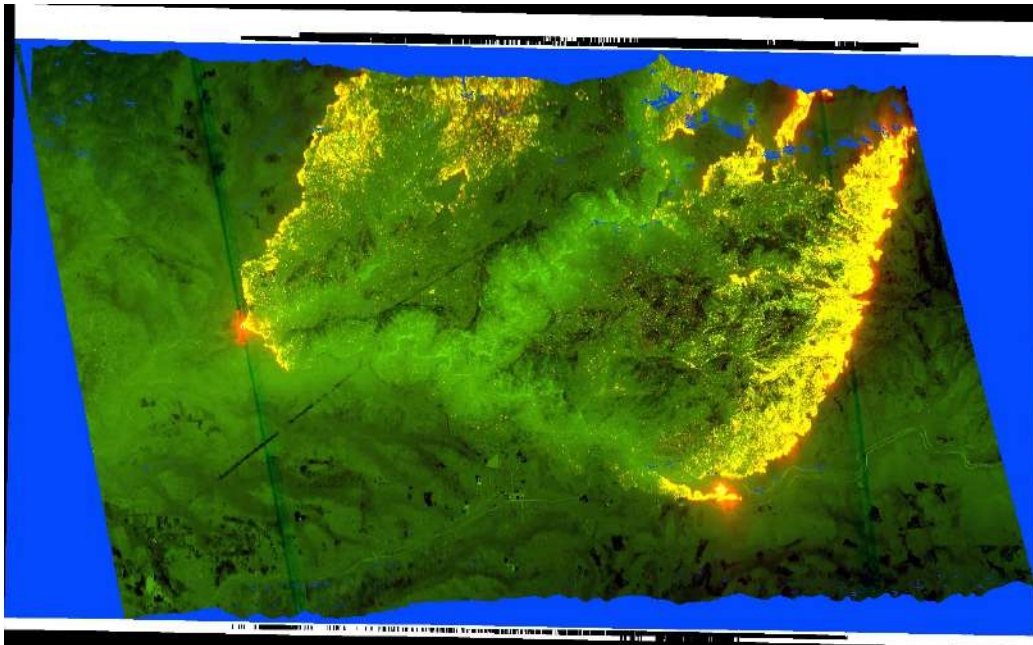
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Wildland firefighting operations face challenges due to:

- Network coverage
- Data portability

Spaceborne & airborne systems routinely provide large data for decision support.



Above: NIROPS image of the King Fire in Pollock Pines, CA.

Access to large, high-value data files can be limited.

- Transfer is slow or not possible for large files (e.g. satellite imagery, video)
 - Insufficient bandwidth/storage
 - Manual process is required
- All data transfers are not possible
 - limited/no connectivity due to:
 - Infrastructure damage
 - Power limitations
 - Insufficient cell tower coverage

Limitations of existing solutions:

- Manual transfer
 - Physical transport
 - Manual data manipulation
- Connecting cables and wires
- “Namespace integration”
- Data corruption (incomplete downloads) during transfer

Project Goal & Impact

Overarching Goal:

To deliver rich and informative data with a robust system that supports file transfer and access across disconnected, heterogeneous networks.

To enhance and extend current operational data sharing capabilities for:

- Improved firefighter and public safety
- Better wildland fire predictions
- More informed fire operations (wildfire and prescribed fires)

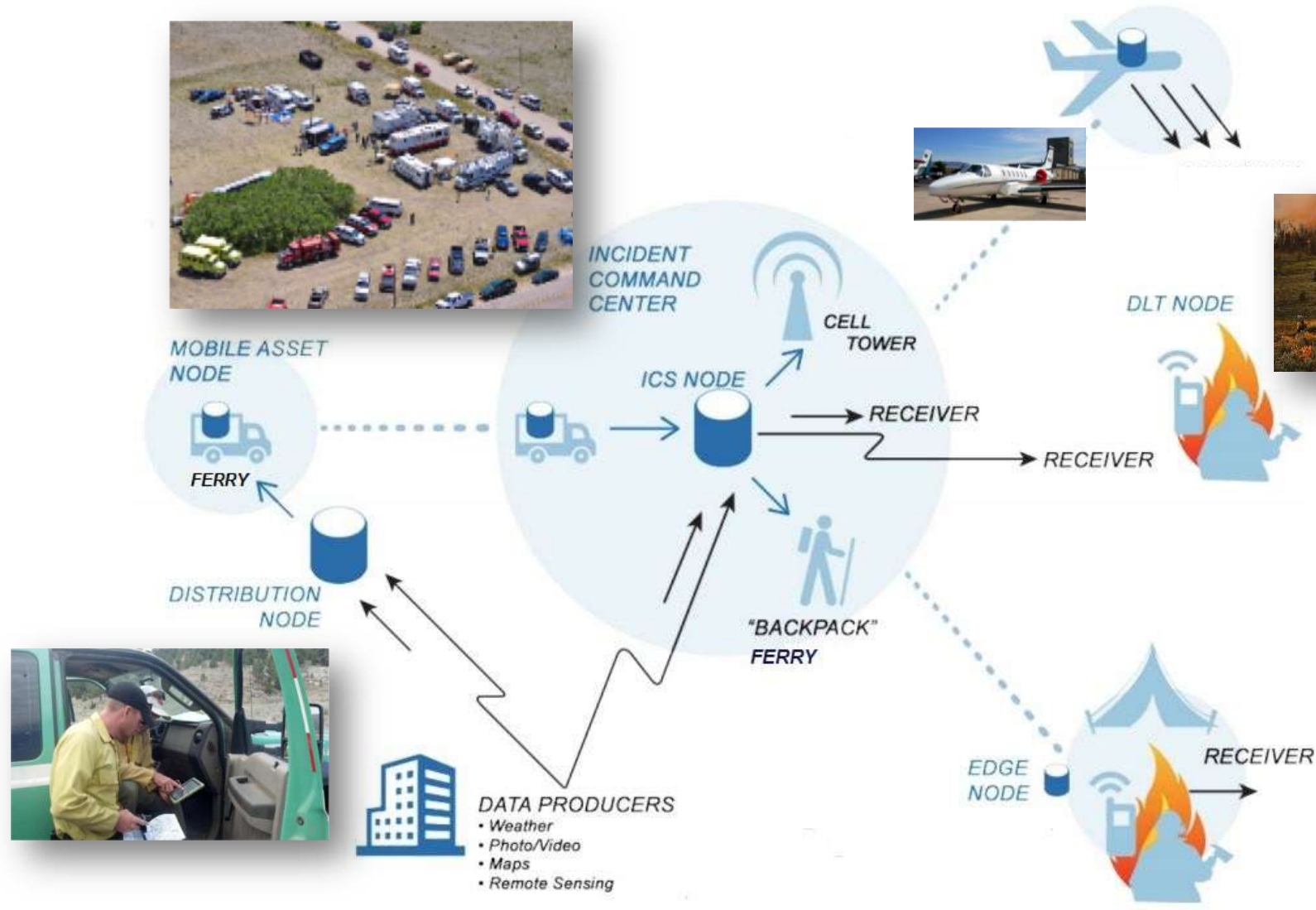
PSCR Vision:

Public safety services and mission critical systems will be able to function properly in situations of poor network connectivity due to natural interference or infrastructural faults.



System Overview

The Wildland-fire Data Logistics Network



**Solution: Develop
hardware/software
tools for data
logistics
→ Data Ferry**

State of Colorado Center of Excellence for Advanced Technology Aerial Firefighting (CoE):

- Development of ATAK-based data access
- Develop an intelligent data ferrying system



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National Interagency Fire Center (NIFC):

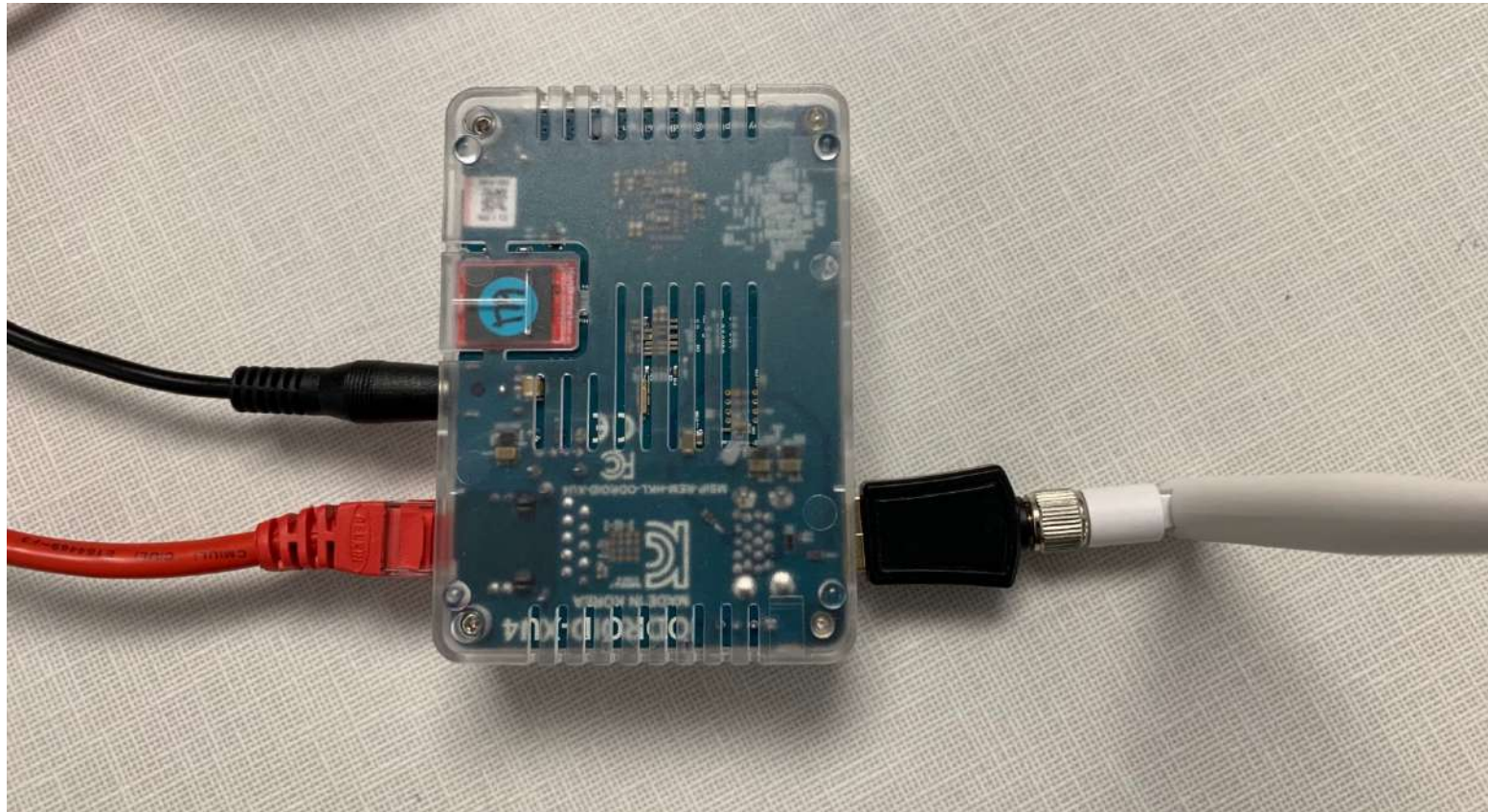
- Identify relevant data needed for ICT/FBAN/LTAN/IMET, etc.
- Improve current methods of moving large data to IC on-site systems



Deploy and test prototype hardware-software system with fire operations personnel that integrates the new data sharing system with existing capabilities and relevant data.

Base Station Hardware

- ODROID XU4 embedded system with WIFI/LORA/GPS
- Support expandable external storage
- Connects to ICS LAN or local laptop for local data staging and distribution



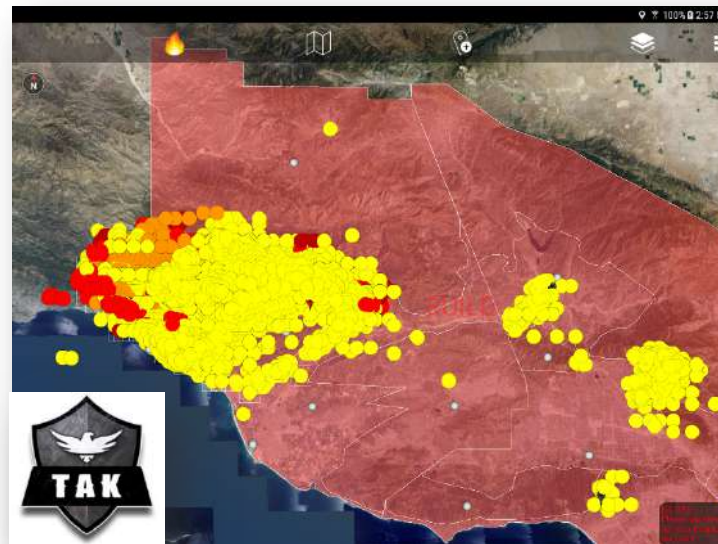
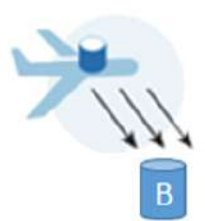
Data Ferry – Field Prototype

- Intel x86 UP board with fast SSD
- Numerous WIFI/LORA/GPS radios
- E-ink display for low-power system status
- HDMI display for logging and debugging
- Battery-driven with solar connection
- Light weather-proofing in initial design



Improving user experience is a fundamental project goal.

- High-performance wireless
 - Low-power signaling
 - To turn on the high-speed wireless when needed (for power conservation)
- Automated/integrated connectivity
 - “Always there with delay”
- Fully automated transfer of data
 - Detection of corruption
 - Re-transmission
 - View-consistency
- ATAK interface
 - Fully developed
 - User-tested
 - Flexible for development
 - (but not the only solution)



- Potential for two-way data sharing (duplex communication)

Base station

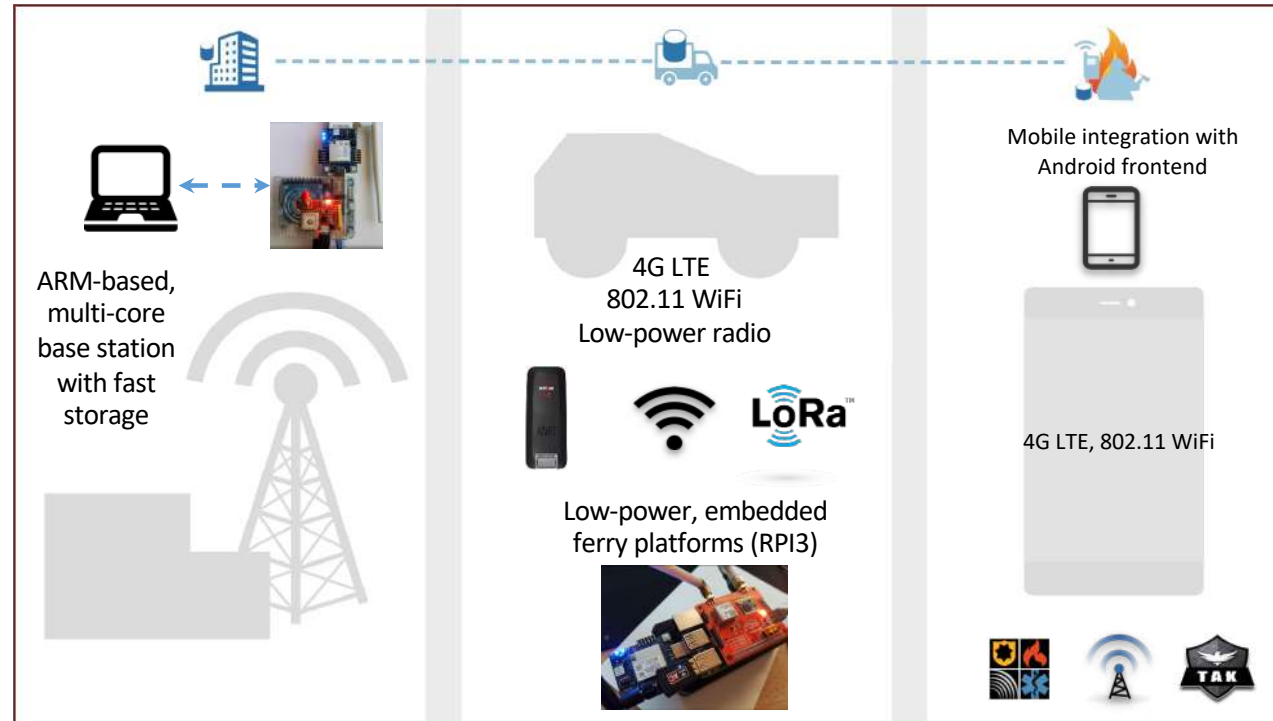
- Access to resources/data
- User-facing web site
- DLT software

Ferry platform

- Ferry software resources
- Communications hardware

Front-end system

- Customized Android-based app (ATAK)



Web-DLT

- User facing web portal

IDMS

- Data distribution manager

Periscope

- Metadata storage database

IBP Depot

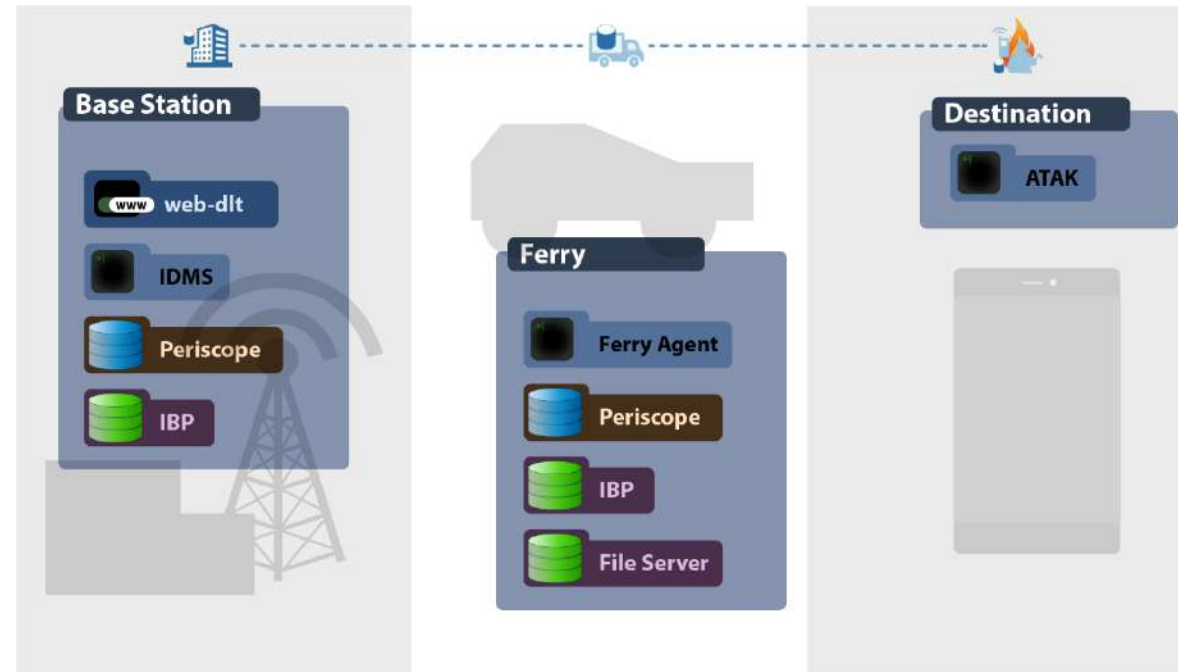
- Block data storage

File Server

- Web Mapping Service (WMS)
- DLT and HTTP

ATAK

- Mobile data client

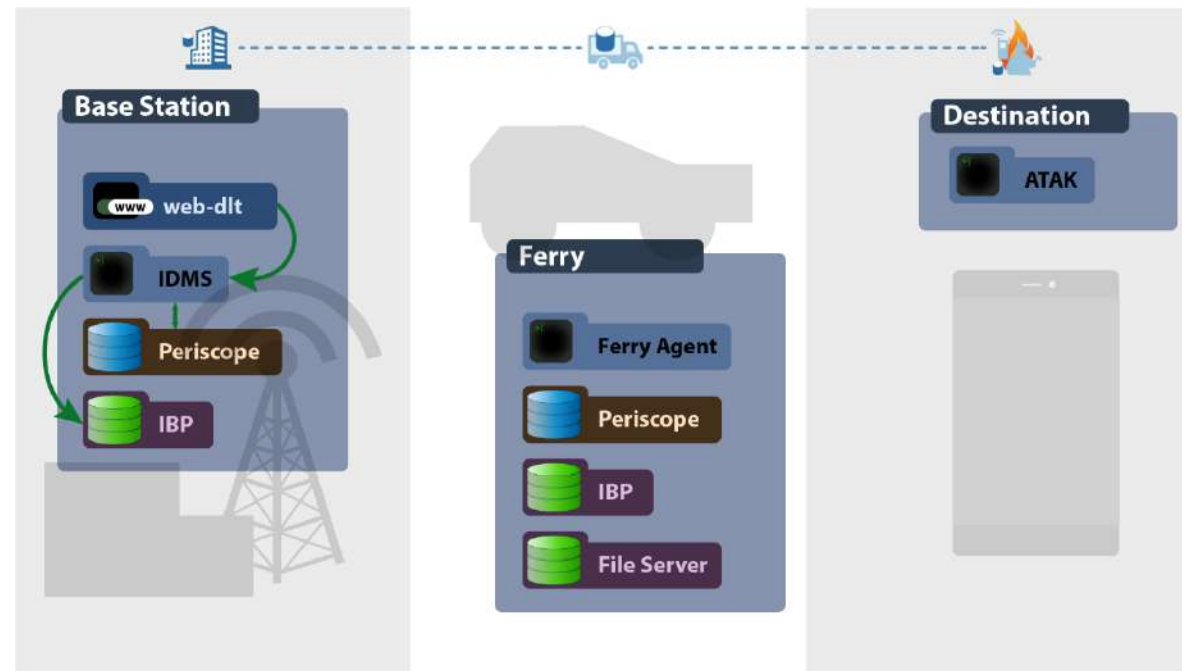


Data Request

Coordinator selects file to be sent to specified locations using the web-dlt portal

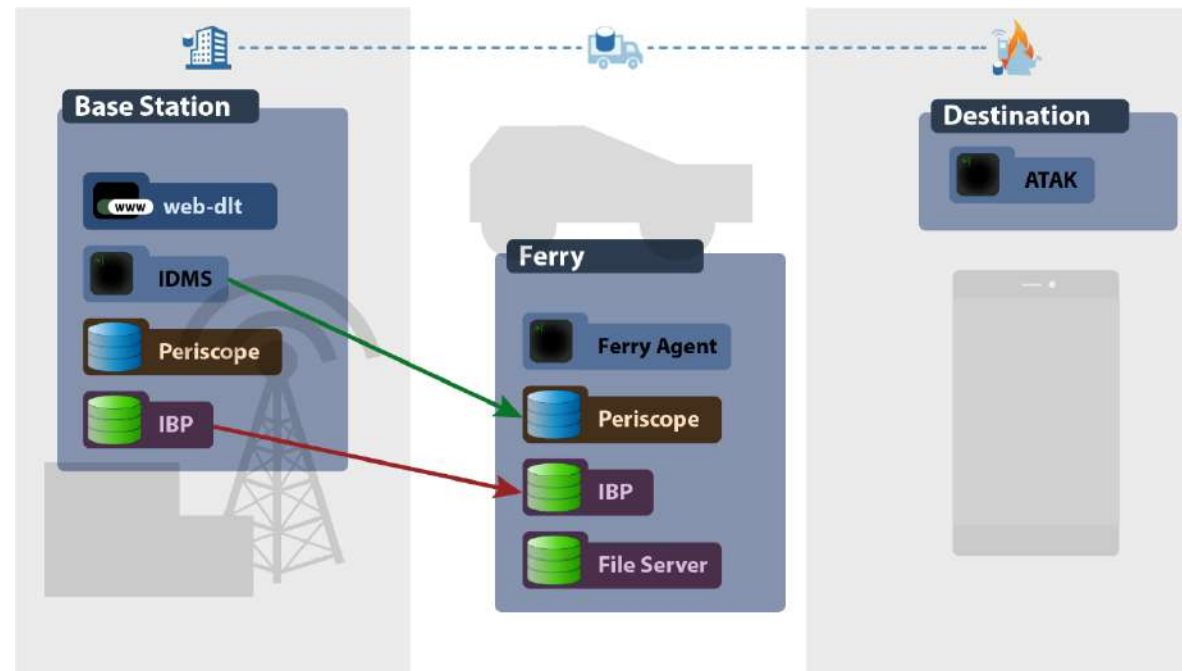
IDMS prepares the data for distribution:

- Records the request for bookkeeping
- Uploads the data to IBP, possibly from distant networked sources



After IDMS detects a ferry bound toward the destination:

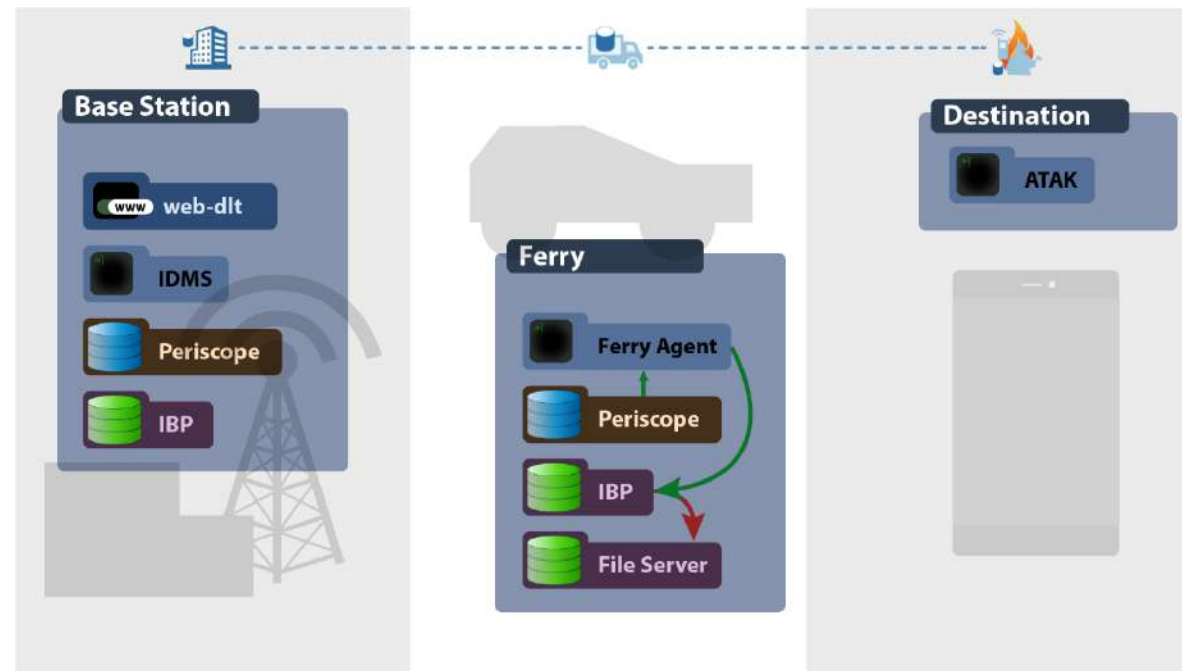
- IDMS records the transaction onto the ferry
- IBP transfers the data onto the ferry



Ferry Enroute

While the ferry travels:

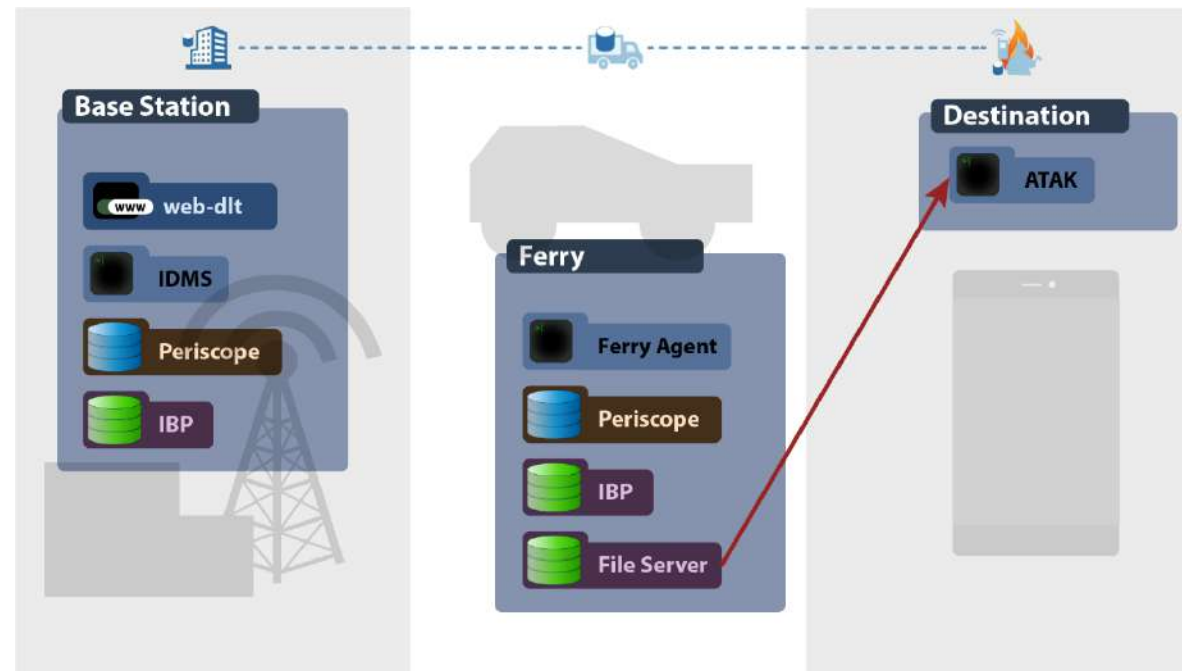
- The ferry agent downloads all data placed into IBP into a local file server
- File server is available for external downloads



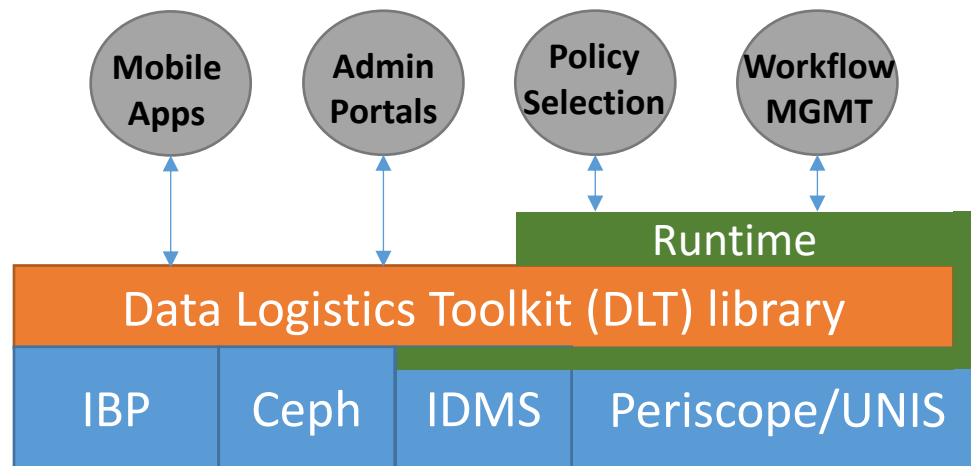
ATAK Download

When the destination detects the ferry's local WiFi:

- ATAK automatically downloads all new files available on the ferry's file server
- Ferry locations are visible as a map overlay



- Local operation – decentralized federation of available nodes and connected devices
 - Dynamic architecture that operates over intermittently connected and heterogeneous networks
- Logistical data distribution – managed workflows for prioritizing and filtering data of importance over geographic and/or temporal criteria

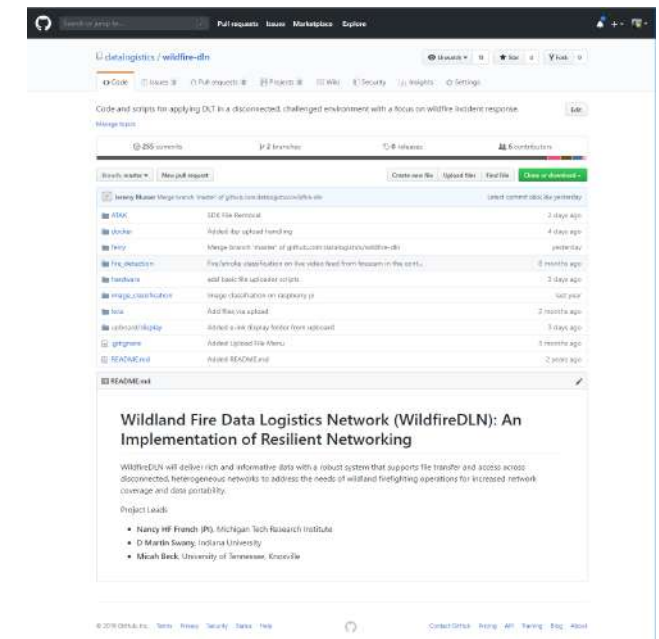
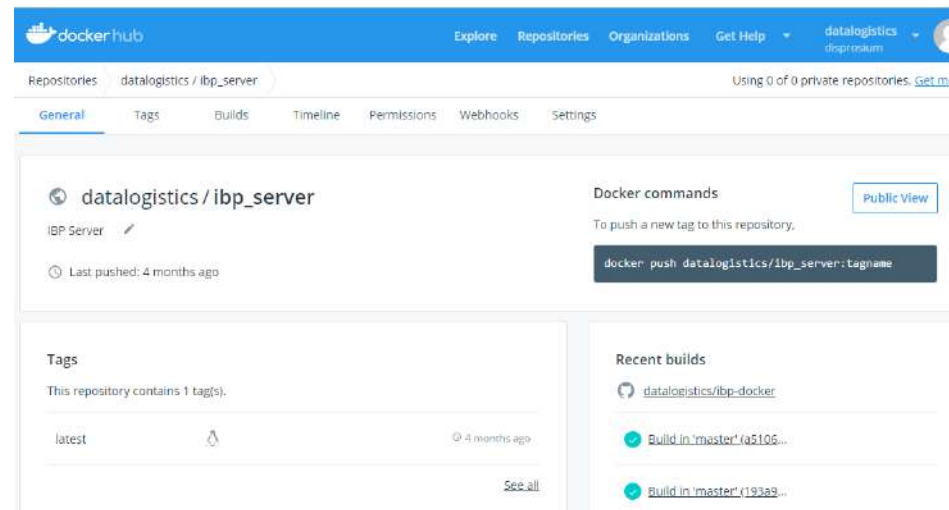
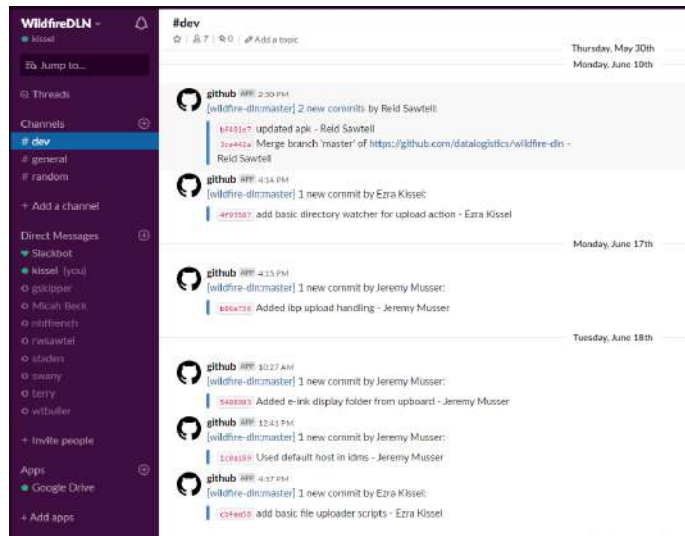


- IBP/Ceph – Object store services
- IDMS – Intelligent Data Movement Service
- Periscope– Network topology and measurements via UNIS (database)

<http://data-logistics.org>

Development Process

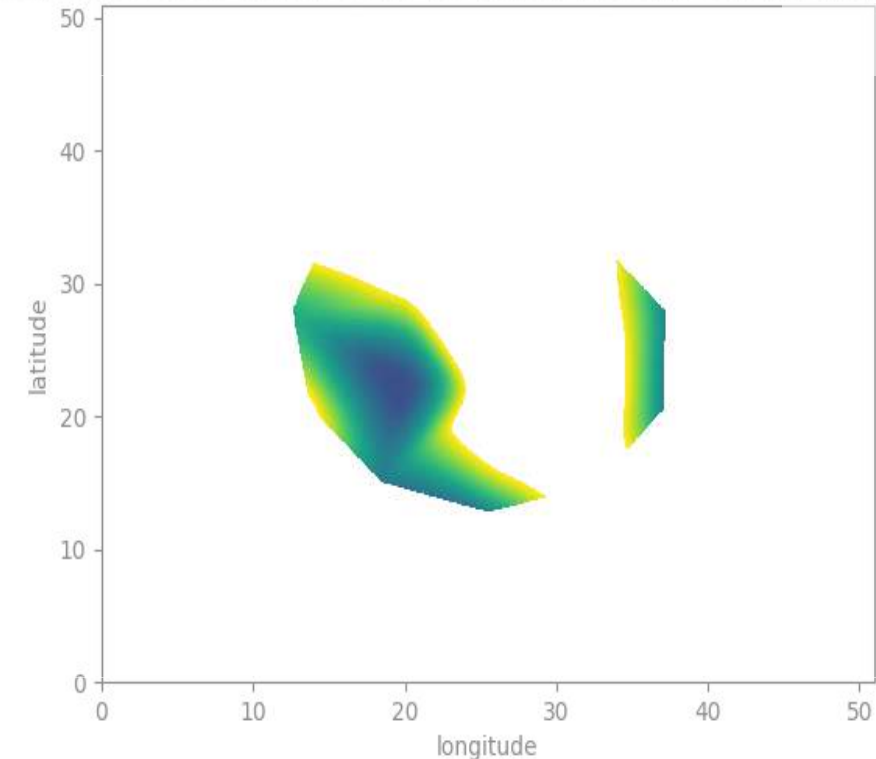
- Two teams collaborating on a common goal:
 - Michigan Tech (Android plugin, hardware assembly and testing)
 - Indiana University (DLN software stack, policy engine, testing in simulation and hardware testbed)
- Used Github and Slack effectively to communicate and share progress
- Docker images were very useful for rapid development and prototyping
 - Available at <https://github.com/datalogistics/wdln-docker>



Ongoing work: LoRa for Efficient Long-Range Communications and *in situ* Model Building

- LoRa provides long-range, power-efficient communications that when utilized by a sufficiently geographically dense set of nodes can generate a mesh that fully exploits the expansive data collection capabilities of software-defined radio.
- Since devices can hear the chatter around them, nodes gain expansive but localized knowledge that can be compressed via model (statistical or otherwise), which then can be communicated to other nodes. This reduces bandwidth requirements as nodes gradually build an ensemble model that is continuously updated for analytics in the field.

Composite contour map of locally interpolated, simulated temperature value



The figure above is a composite of per-node models of simulated temperature data heard in radio chatter in a virtual deployment of 50 nodes, placed in an efficient spiral pattern. Each node collects observations then constructs a model via cubic spline interpolation, yielding a collection of localized temperature models.

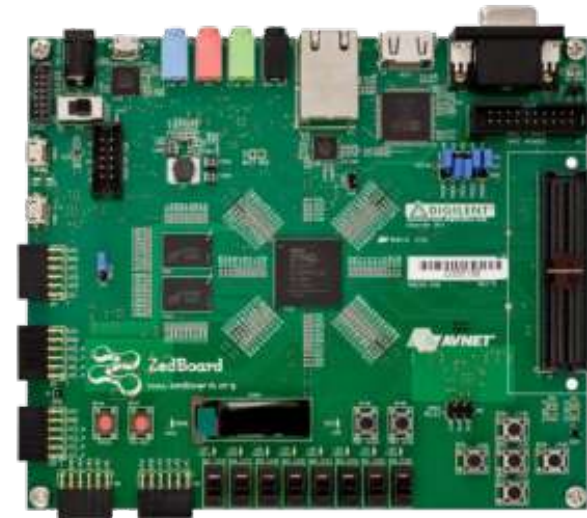
- Targeting microservices for network-oriented Edge computing led us to explore a simple execution model and runtime we call InLocus
- The goal is to support stream processing of sensor data in the network across a variety of simple, small platforms
- A lightweight alternative to “Docker on Linux”



NodeMCU
ESP8266



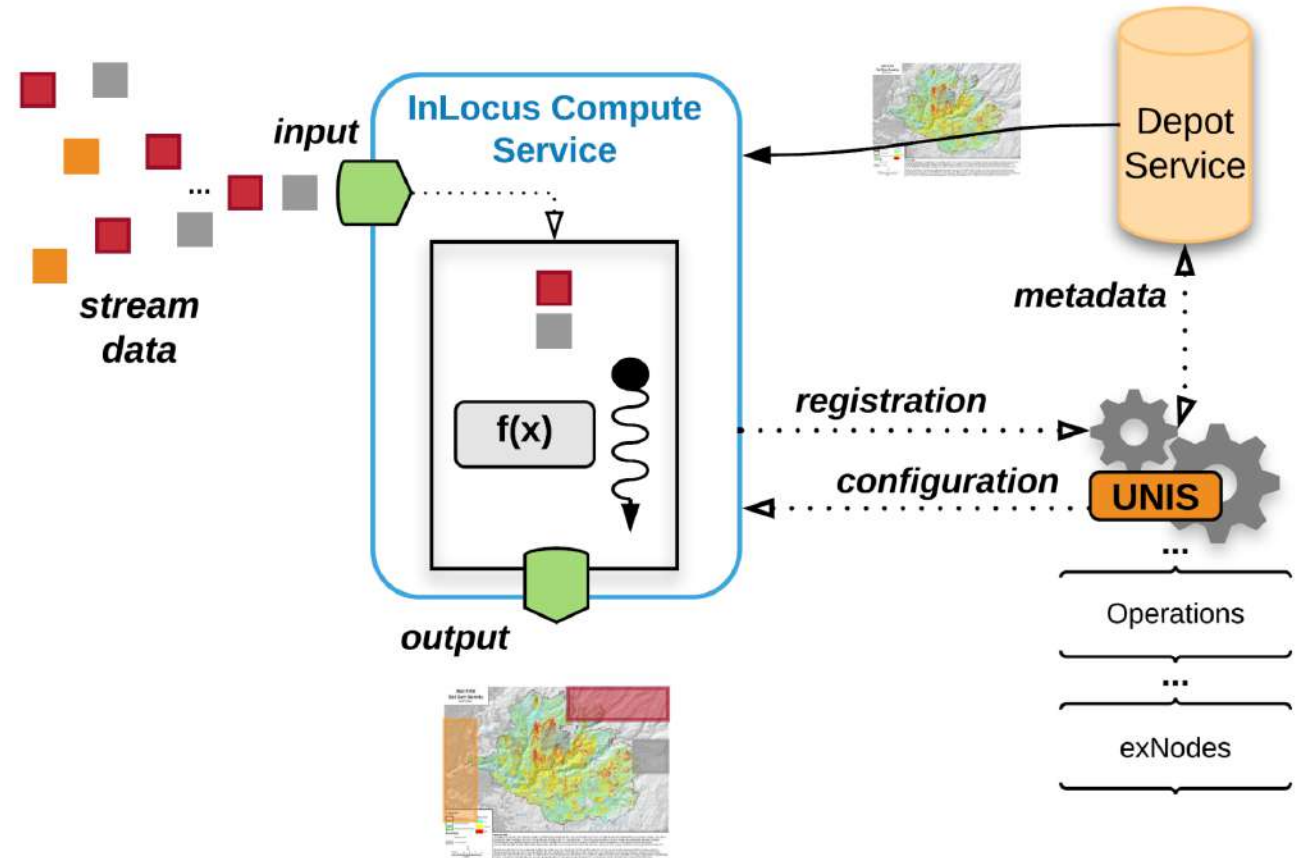
BeagleBone Black



ZedBoard with Xilinx Zynq 7000

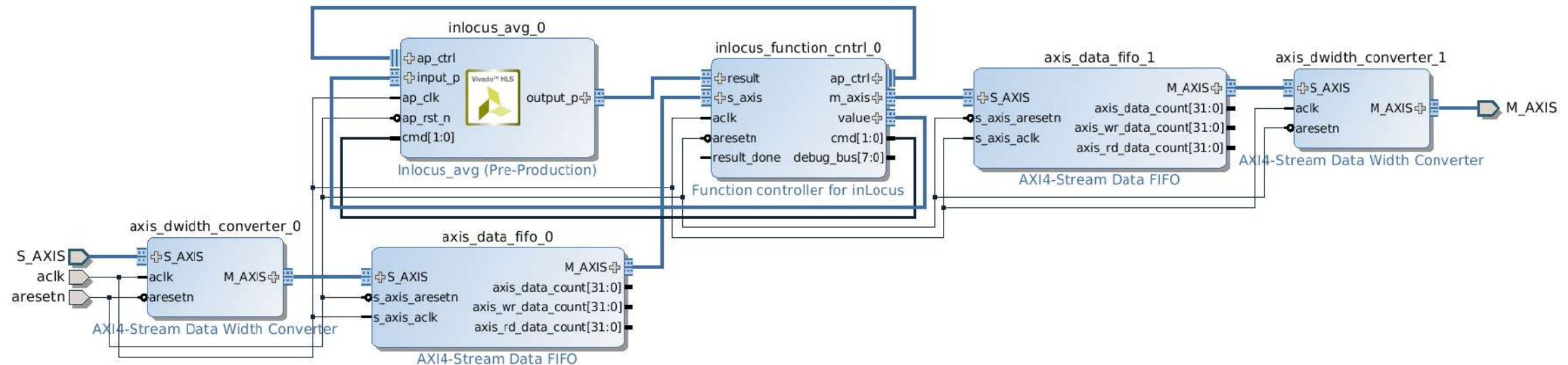
The InLocus Model

- Compute services apply operations on stream data
 - Imagery, video, sensor, etc.
- Storage may provide static content for data fusion
- Operations controlled dynamically by UNIS and global orchestration



Implementation

- Streaming sensor data in timestamp, value tuples
 - CoAP/CBOR messages
- C and Node.js reference implementations
- Programmable logic infrastructure with HLS summarization function



Results – Where does the time go?

Component	Mean (%)	Std Dev (%)	Time (μ s)
Kernel	51.62	0.22	101.84
GlibC	18.68	0.18	36.85
libCoAP	13.43	0.15	26.50
libCBOR	13.37	0.08	26.38
Arith_avg	0.06	0.01	0.12

L. R. B. Brasilino, A. Shroyer, N. Marri, S. Agrawal, C. Pilachowski, E. Kissel, and M. Swany. Data Distillation at the Network's Edge: Exposing Programmable Logic with InLocus. In *IEEE International Conference on Edge Computing*, July 2018.

- Work with wildland fire experts to demonstrate the ferry-based data transfer process
 - With relevant data sets
 - In real-world environment
- Data Ferry hardware/software for testing and further development
- Results of survey and other feedback from wildland fire responders
 - What do they need
 - What would help and how
 - What is currently lacking re: data/information resources
- Reports on performance of system
 - Include metrics for development and operation of system
 - Cost
 - Operation solutions
 - Feasibility of adoption
 - Include testimonials from wildland fire community who have helped with demonstration testing

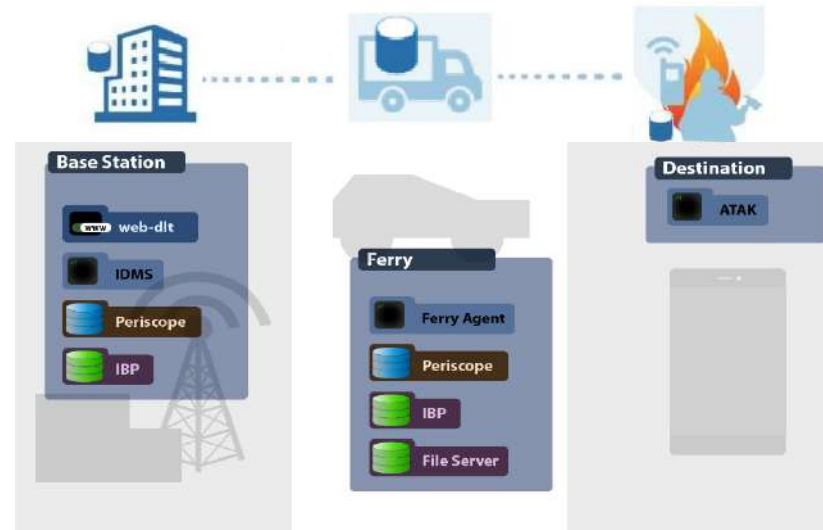


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WildfireDLN project team will show a technical demonstration this afternoon

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Session**
10:35 AM