UPISC UNIVERSITY OF PITTSBURGH INFRASTRUCTURE SENSING

COLLABORATION WORKSHOP

NATIONAL ENERGY TECHNOLOGY LABORATORY

Christopher Ziolkowski

R&D Manager, Sensors and Automation, GTI Energy

Joining GTI in 1982, Chris has worked on a wide variety of utility industry projects involving electronic hardware, digital signal processing, wireless communication, firmware, and software design for field environments. He directs sensors, data acquisition, communications, and embedded development efforts at GTI. Chris has worked on several distributed wireless sensor deployments and in the area of Machine Learning. He has worked with the LoRa Alliance and the Wi-SUN Alliance to promote an open standard ecosystem and interoperability in the wireless sensor space.

Sensor Data Communication, Integration, and Analytics

Chris Ziolkowski
Institute Engineer

UPitt Infrastructure Sensing Collaboration Workshop - August 25, 2022

GTI ENERGY
solutions that transform

GTI Energy Background

GTI ENERGY

- GTI Energy is a leading research and training organization focused on developing, scaling, and deploying innovations that support low-carbon, low-cost energy systems.
- Our energy solutions transform lives, economies, and the environment.
- We embrace systems thinking, open learning, and collaboration to solve for some of the world’s greatest energy challenges.
- With 28 laboratory facilities and five offices across the U.S., GTI Energy leverages the expertise of our trusted team of scientists, engineers, and partners to deliver impactful innovations needed for low-carbon, low-cost energy systems worldwide.

GTI ENERGY

Working across the energy value chain

Source

Expanding supplies of affordable, clean energy

- Subsurface production of hydrogen
- Enhanced geothermal systems
- Unconventional natural gas and oil production
- Geologic modeling and reservoir characterization
- Hydraulic fracturing diagnostics and optimization
- Hydraulic fracturing and reservoir flow modelling
- Enhanced recovery

Make

Transforming natural resources into clean energy

- Hydrogen production
- Integrated biofuels technology R&D
- Syngas generation and processing
- Carbon management
- CO_2 capture and utilization
- Chemical research and process development
- Renewable natural gas and gas quality
- Gasification process development

Move & Store

Ensuring safe and reliable energy infrastructure

- Methane emissions, monitoring, mitigation, and reduction
- Data integrity and risk management
- Infrastructure rehabilitation and improvements
- Environmental matters, enabling renewable gas, and gas quality
- Smart utility information technology tools
- Materials and analytical testing
- CO_2, H_2, and natural gas underground storage

Use

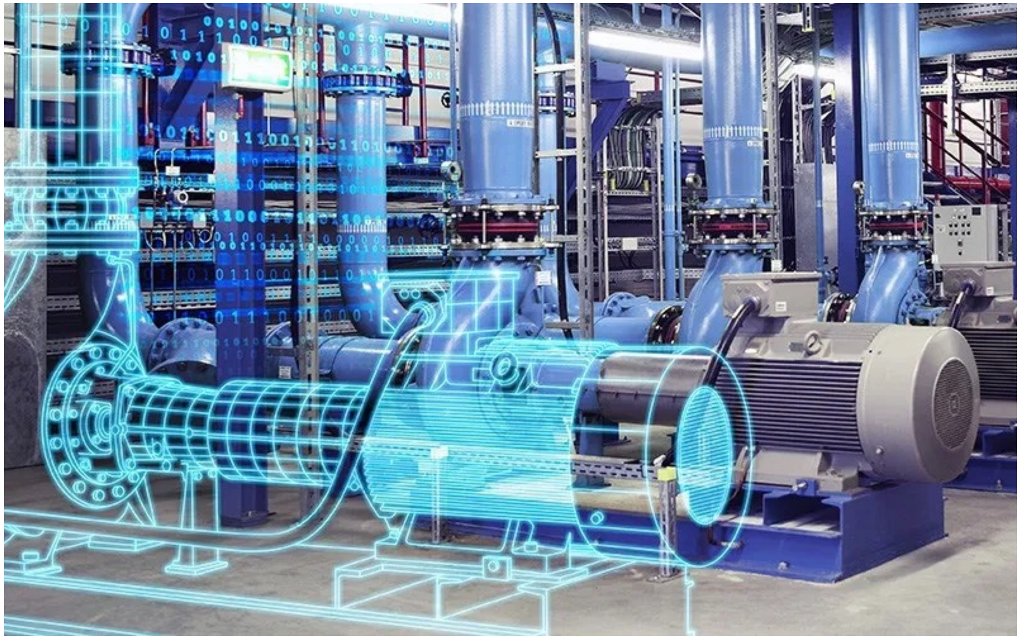
Delivering solutions for efficient and environmentally responsible energy use

- Residential/commercial appliances, equipment, and building systems
- Industrial process heat and steam
- Power generation and combined heat and power
- Alternative transportation fuels
- Natural gas-solar thermal hybrid equipment
- CO_2 capture and utilization

The objectives of this presentation:

GTI ENERGY

- Explore the data value chain from the sensor to the end user.
- Discuss the digitalization of sensor data.
- Discuss Machine Learning as a tool to facilitate digitalization.
- Examine how IoT is an enabler for digitalization and ML.



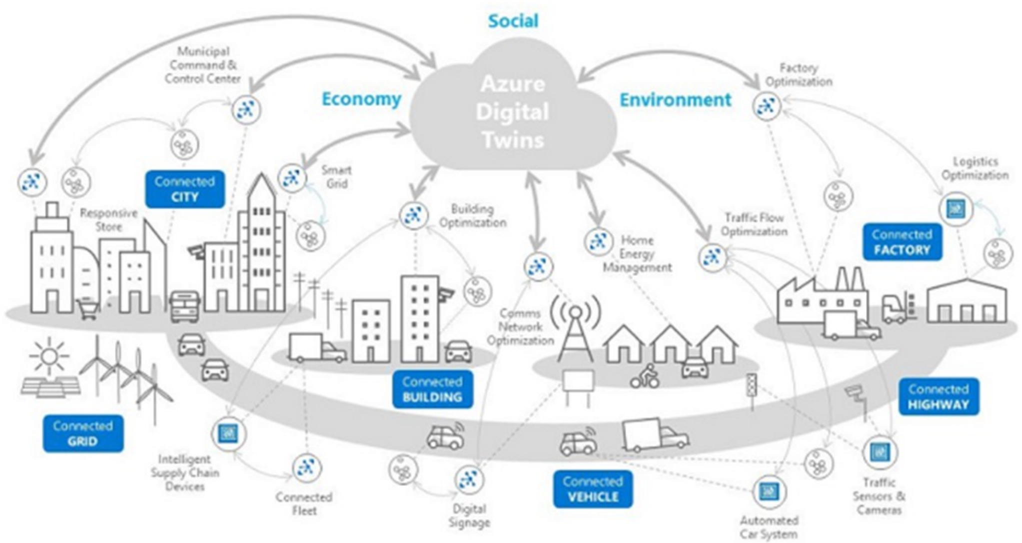
Utilities need to maintain two major artifacts:

GTI ENERGY

- The physical utility infrastructure and;
- The data of record describing that infrastructure.
  - Decisions made about one are based on the other.
  - Good decisions require data that is complete, current, and accurate.
  - Sensor data can keep the physical and digital worlds in sync.

What is the ideal state of your data?

- Accessible through a single portal.
- Visible on desk, tablet, or phone.
- Accuracy/age of the data is known.
- Geospatially aligned with physical infrastructure.
- Updated at appropriate intervals.
- Complete across business functions.



IoT

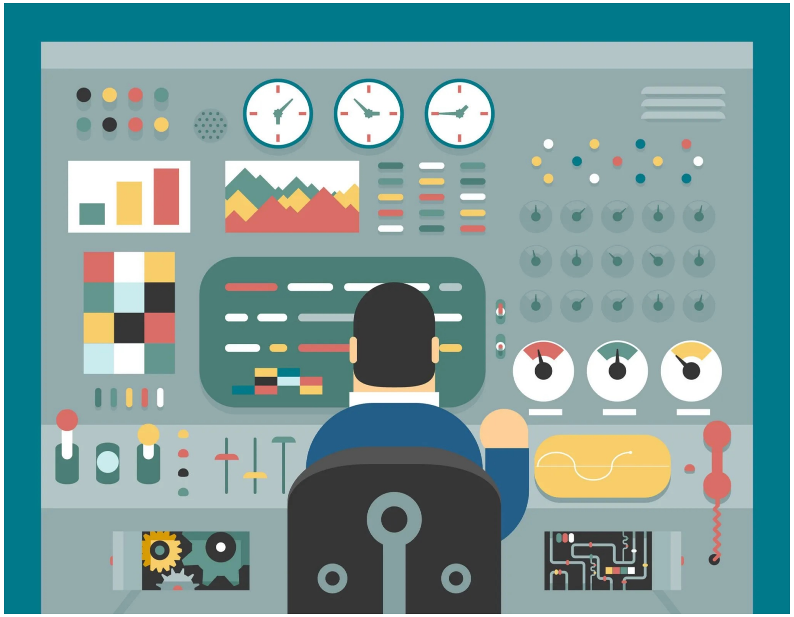
INTERNET OF THINGS IN THE UTILITY OPERATIONS INDUSTRY

What is the Internet of Things?

GTI ENERGY

- IoT is not a device; it is an ecosystem.
- IoT is not tied to a single vendor; it is interoperable across vendors.
- IoT is not proprietary; it is based on open standards.
- IoT is not static; it is a toolkit for adapting to change.
- IoT connects operators to their infrastructure in a timely manner.

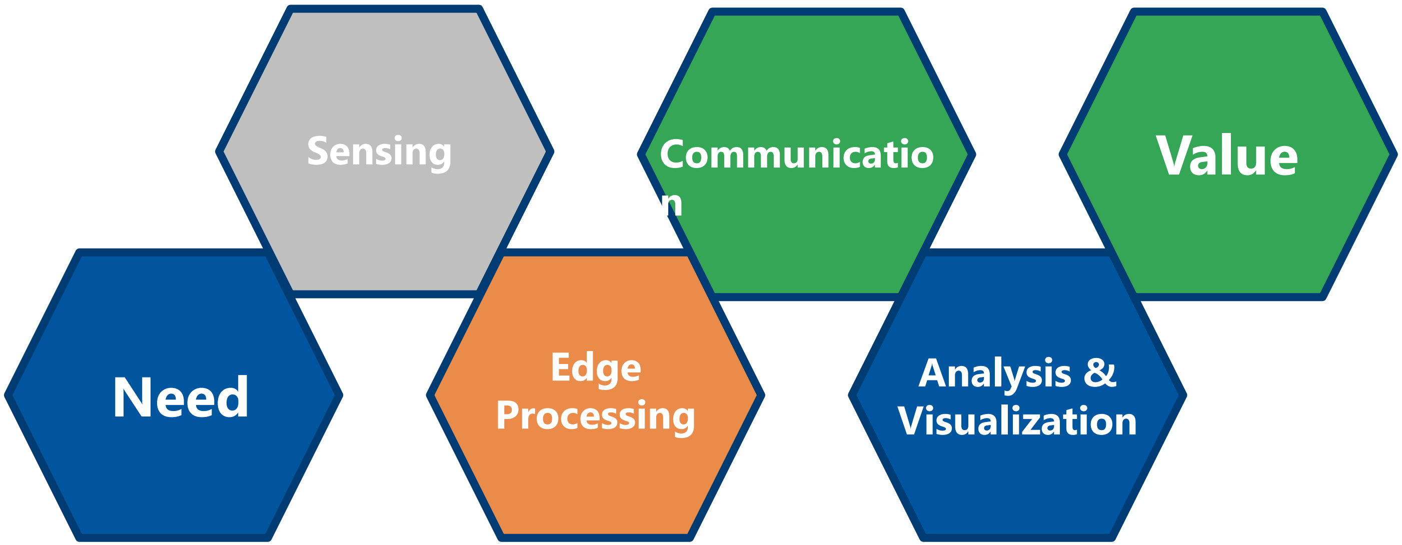
Why use the Internet of Things?



- Supervisory Control and Data Acquisition (SCADA) systems are optimized to do certain tasks very well.
- SCADA can deliver high volume data with 50 mS latency and is priced accordingly.
- Several IoT installations can be fielded for the cost of single SCADA installation.
- Some applications benefit from broad versus narrow view of infrastructure.
- IoT can be more cost effective where small latency can be is acceptable.

IoT Connects the Operator to Needed Data

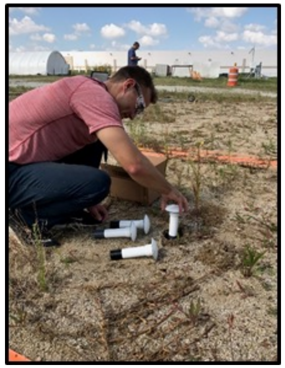
GTI ENERGY



Examples of Utility IoT Based Sensors

GTI ENERGY

Unattended Methane Monitor



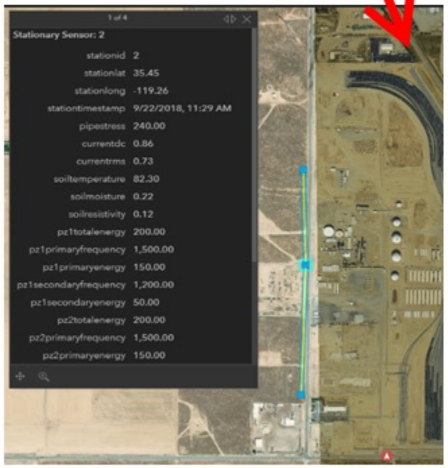
Remote Pressure Sensing

ROW Intrusion Monitoring

Residential Methane Monitoring

Example: Sensor-Based ROW Monitoring

GTI ENERGY



Sensors installed on/near pipe detect activity in the ROW and forward alerts to a cloud-based dashboard.

Example: Continuous Stationary Monitoring

- Continuous monitoring of emissions from a remote utility facility.
- Unattended operation with wireless transfer of data.
- Equipment was off-the-shelf.
- Analytics were developed for the specific case.

What are the components of IoT?

GTI ENERGY

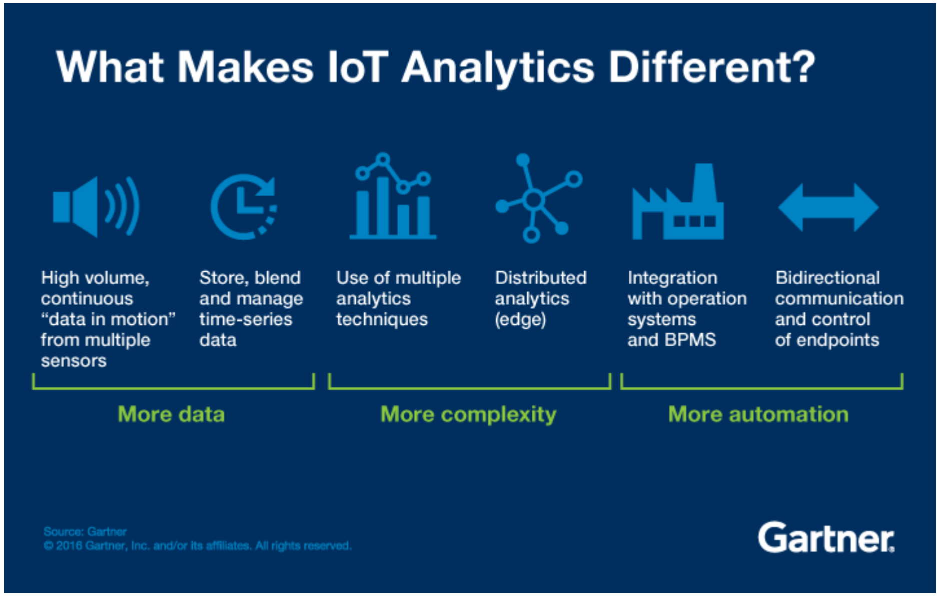
- A portal for data visualization and manipulation at the operator edge.
- Analytical tools to work with the data.
- Open standards for communication and interchange of data.
- Data storage accessible from the operator side and from the sensor side.
- External (to the utility) data sources such as weather, fires, seismic, or markets.
- Sensors and actuators at the physical infrastructure edge.

A deeper look at the components of IoT

- **Analytical tools:** Machine Learning is an important part of the analytical toolbox. ML enables the behavior of complex systems to be modeled rather than just recorded.
- **Normalized data:** Utilities need an orderly store of training data to model the physical plant accurately. This is the shared "memory".
- **Open standards:** TCP/IP standards are the "internet" component that makes the communication of data seamless.
- **Sensors:** These physical devices touch the system being monitored and modeled. They require the other components to keep the data store up to date.

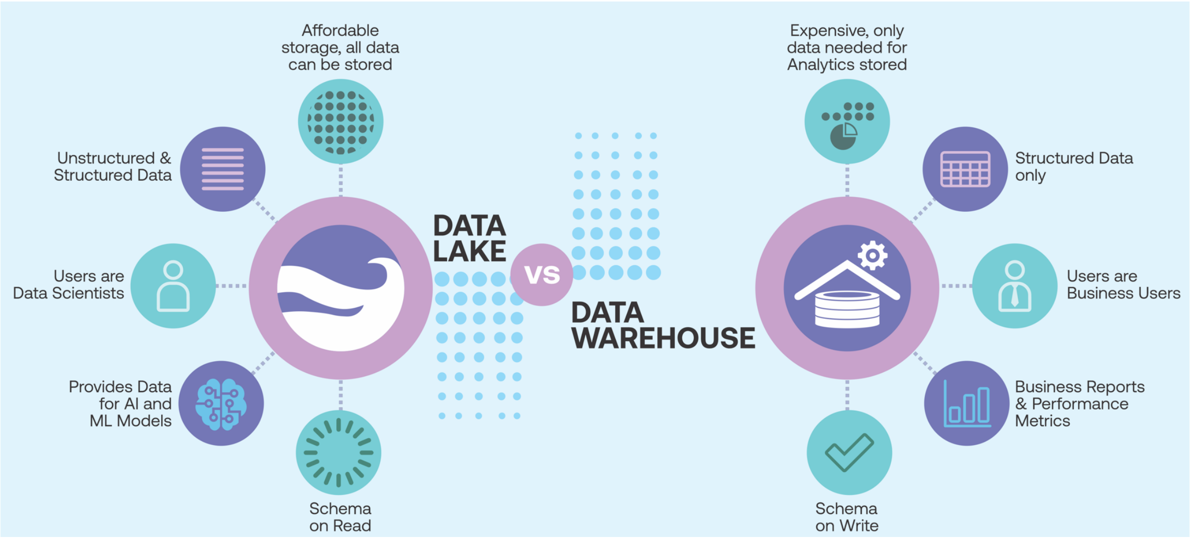
IoT Analytics

- IoT enables (requires!) different approaches to analytics.
- Automation of analytics will be needed to handle the volume of data.
- Traditional "control room" approaches risk overwhelming operators.
- The desired goal is actionable information, not just more data.



IoT Data Storage

- Data describing the infrastructure in geospatial context is the cornerstone of digitalization.
- Current developments allow you to "store now and format later".
- No need to define schema in advance of saving data and then having to change the schema if your data or needs change.

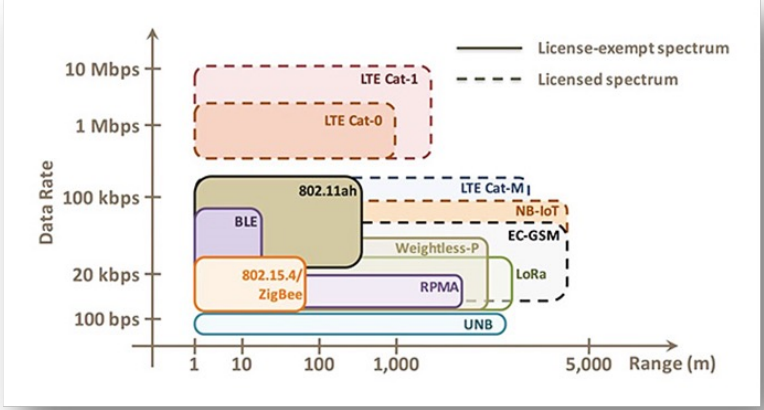


Wireless Network Choices

GTI ENERGY

- Dependent on application throughput, power, and range requirements.
- Dependent on your organization's supported networks and infrastructure.

- Low-Power Wide Area Networks (LPWAN)
  - Built for machine-to-machine(M2M) communications.
  - Small packets, infrequent transmissions, low power, harsh wireless environments.
  - LoRaWAN, Sigfox, RPMA, LTE-CATM1, NB-IoT.



The Challenge of IoT and Digitalization

GTI ENERGY

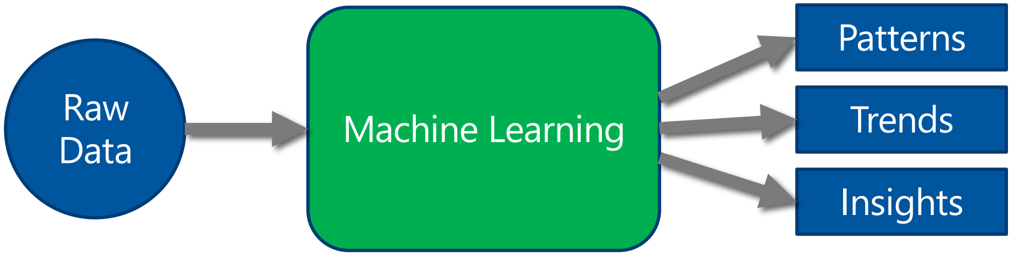
- The volume of data we need to deal with is at a tipping point:
  - Data can grow into a structure, or
  - Data can simply expand into entropy!
- Utilities need to turn their data into knowledge without further burdening human analysts.
- Machine Learning (ML) is a tool that can assist in structuring this data.

ML

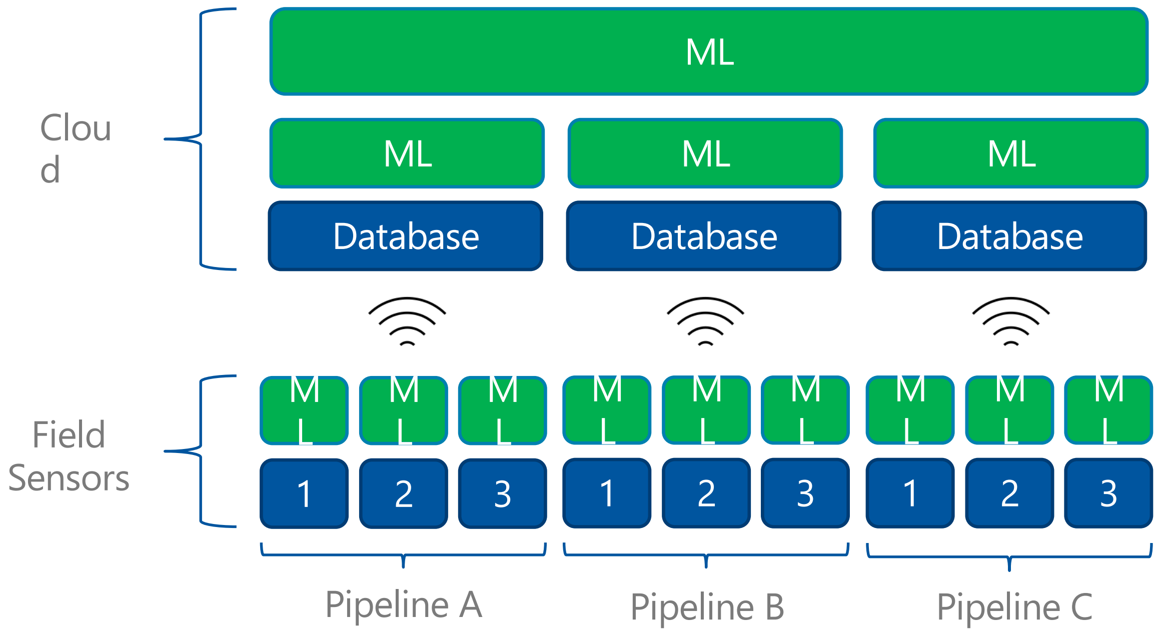
MACHINE LEARNING IN THE UTILITY OPERATIONS INDUSTRY

What is Machine Learning (ML)?

- A tool for using existing data to build an algorithm.
- ML algorithm vs Traditional algorithm.
- ML enables algorithm development on large complex datasets.
- Accurate ML algorithms require large sets of high-quality data.



Where can ML be applied?



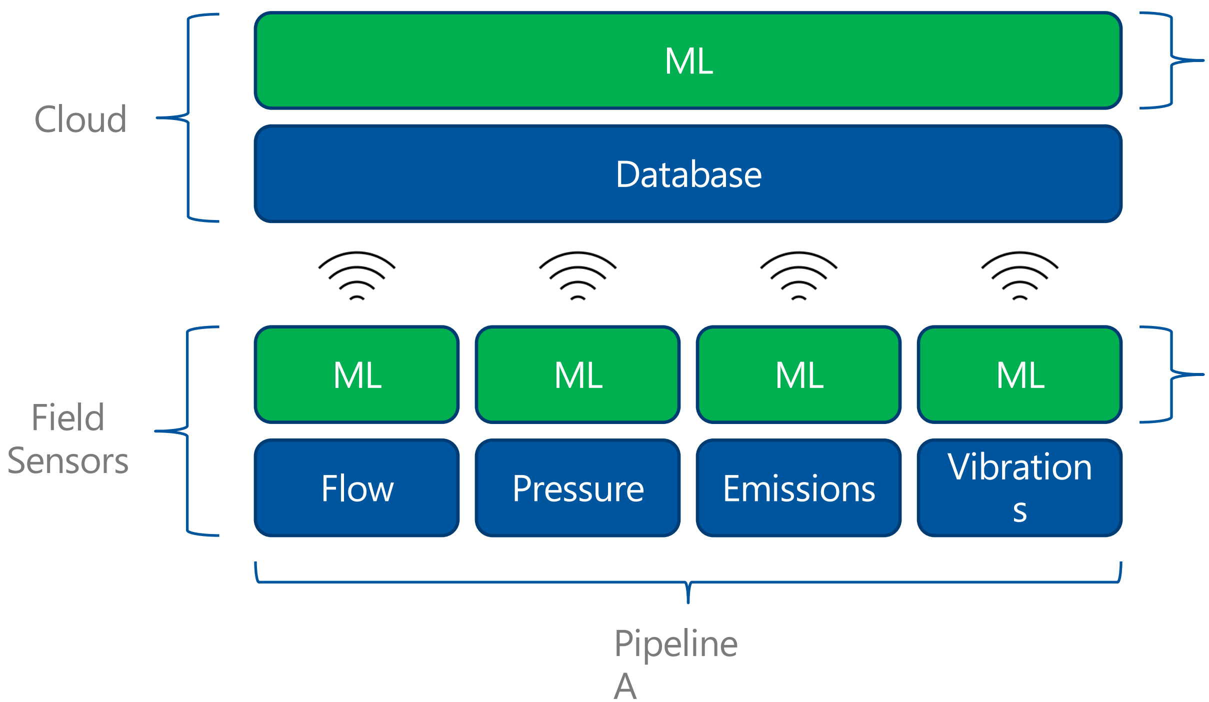
ML assigns meaning across many pipelines within a utility.

ML assigns meaning across many field sensors on an individual pipeline.

ML assigns meaning to individual field sensors immediately upon collection.

ML at the Edge Sensor Level

GTI ENERGY

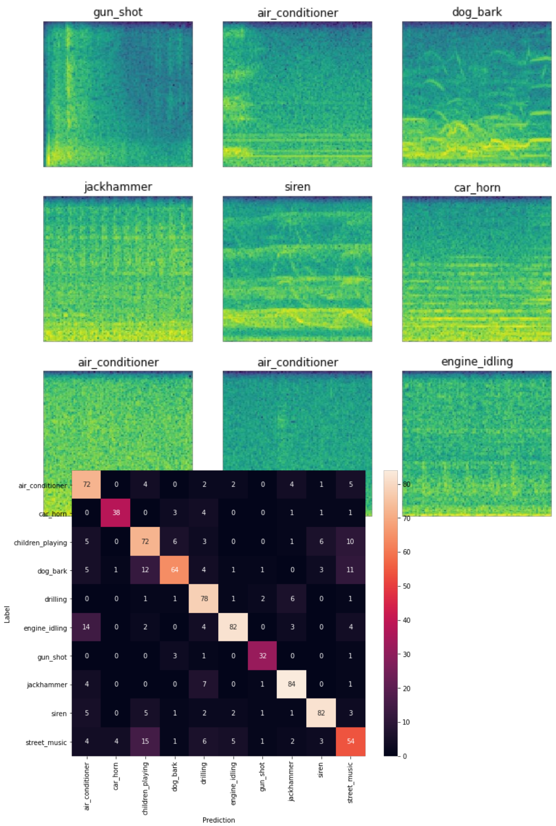


ML assigns meaning across multiple field sensors on a particular pipeline.

ML assigns meaning to the readings locally, characterizing and transmitting only important information.

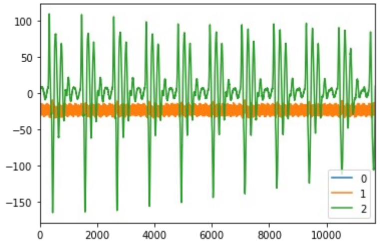
Sensor Level ML Example

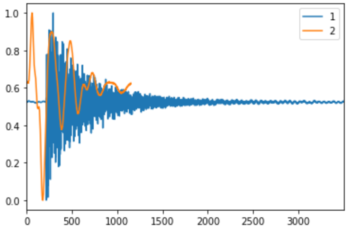
- Sound classification in the ROW.
  – *Large equipment, jackhammers, other threats.*
- Characterize sounds locally, without continuous wireless access to a cloud.
- Only transmit the characterization of the sound.
  – *Reduce data transfer, reduce wireless activity, save power.*



Sensor Level ML Example

- Vibration Analysis in the ROW.
  - *Direct contact with pipeline or surrounding soil.*
- 3rd party excavator damage, activity above buried pipe, soil movement, pipe stress.
- Characterize signal patterns locally, without continuous wireless access to a cloud.
- Only transmit significant events and be able to differentiate between types of events.





GTI ENERGY

Conclusions

- The tools of IoT connected sensors and ML can drive Digital Transformation, providing the utilities with timely information on their infrastructure.
- The captured data must be stored appropriately, geospatial referencing is preferred for utility applications.
- A "digital twin" of the infrastructure will require these underpinnings to be viable and valuable model.

Thank You
Questions?

CHRIS ZIOLKOWSKI
CZIOLKOWSKI@GTI.ENERGY