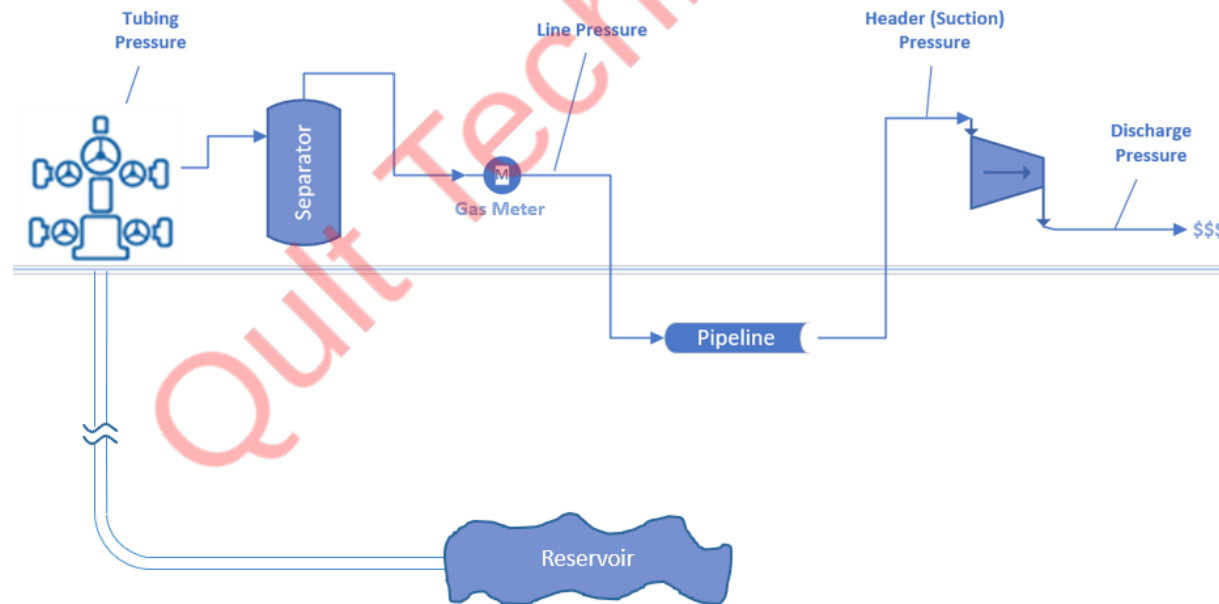


# Pig Route Optimization

Qult Technologies

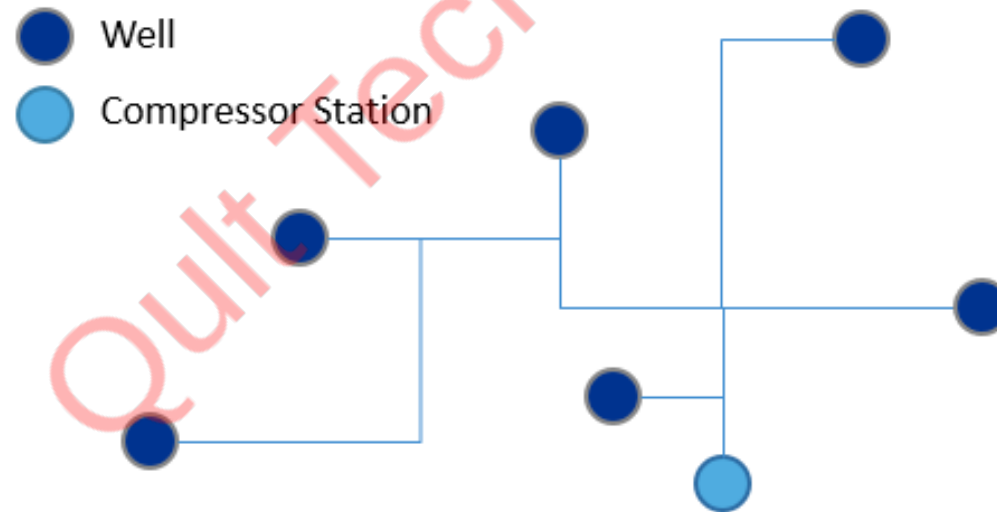
# Gas Gathering System

- Natural gas will travel from reservoir (high temperatures and pressures) to well-head via tubing shown in the above image.
- Separator here will separate (water in this case) liquid from the gas and feed it to the gas meter. Gas from several wells will be collected in the common pipeline.
- Several pipelines fed into center processing facility (CPF) or compressor station.



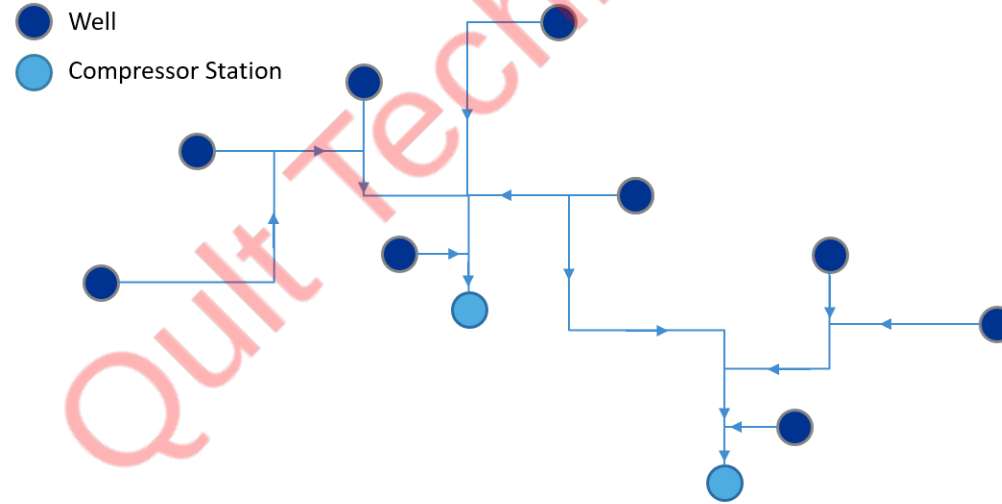
# Gas Gathering System

- A typical gathering system has a one-to-many relationship between the wells and CPFs as shown in blank below (many wells per CPF)
- **Line Pressure:** the back pressure exerted on the well, is measured downstream of the gas metering process
- **Header Pressure:** The pressure upstream of the compressor.
- **Differential Pressure:** The required potential energy spend to move the gas from the well head through the gathering system to the CPF.



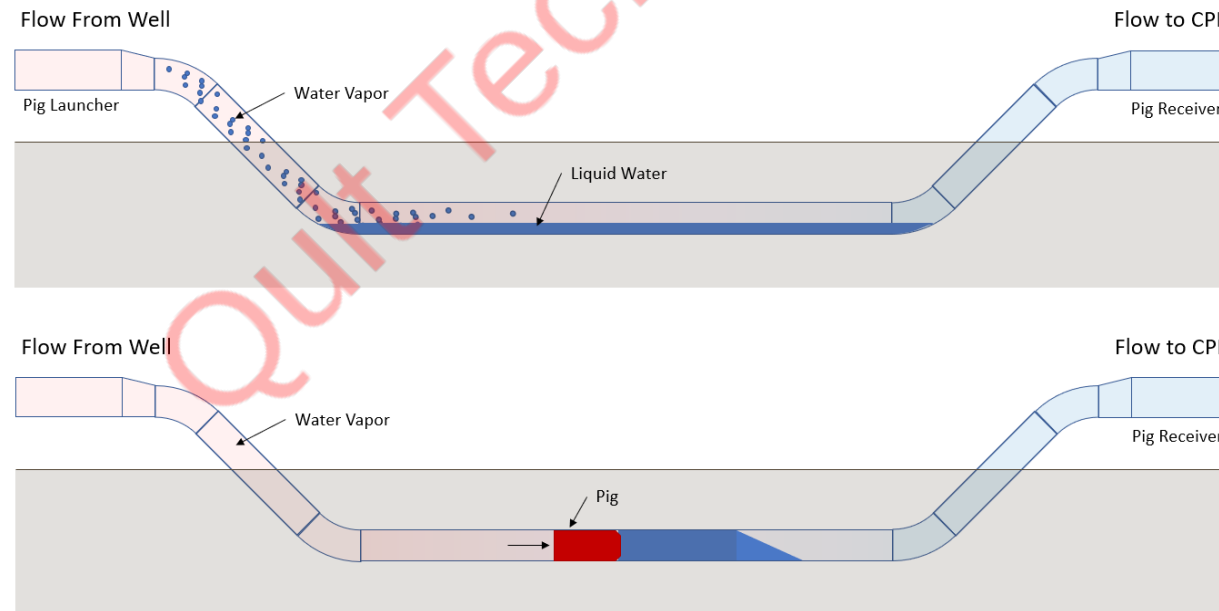
# Gas Gathering System

- Gathering system usually is not very typical but consists of very complex network of wells and CPFs.
- There are many-many relationships between wells and CPFs (compressor stations).
- Below is the simplified version of wells, pipelines and CPFs network but in real life scenarios this system can have >4000 wells and >50 CPF stations.
- As natural gas flow from the pipelines, entrained water will drop out of the natural gas and collect in low points of the pipelines.



# Pipeline Pigging

- Water collected in the low points of the pipelines will restrict the natural gas flow.
  - A process of pipeline pigging is used to remove water collected in the pipelines to restore normal natural gas flow.
  - **Pig Route:** Desired path of travel for the pig.
  - **Pig Run:** Act of running a single pig.
- Pig routes have a one-to-many relationship with the wells that they affect, i.e., removing water from a pig route would positively affect one or more wells. Note that depending on where the water is along the pig route, some wells may benefit, and others may not.



# Data Points for ML Model

- There are five datapoints available for this (This may vary for different oil and gas companies)
  - Well line pressure (at well head)
  - Well gas flow
  - Temperature (not found helpful)
  - Header pressure (at CPFs)
  - Differential pressure ( derived datapoint)
- Relationship between line pressure, differential pressure and header pressure
  - $LP = dP + HP$
- Ultimate objective of any pigging process is to minimize dP (differential pressure) and to maximize well gas flow.

# Data Points EDA

## There is no restriction in the pipeline:

- Line pressure positively correlated to the gas flow. As gas flow increases line pressures increases due to large frictional losses.

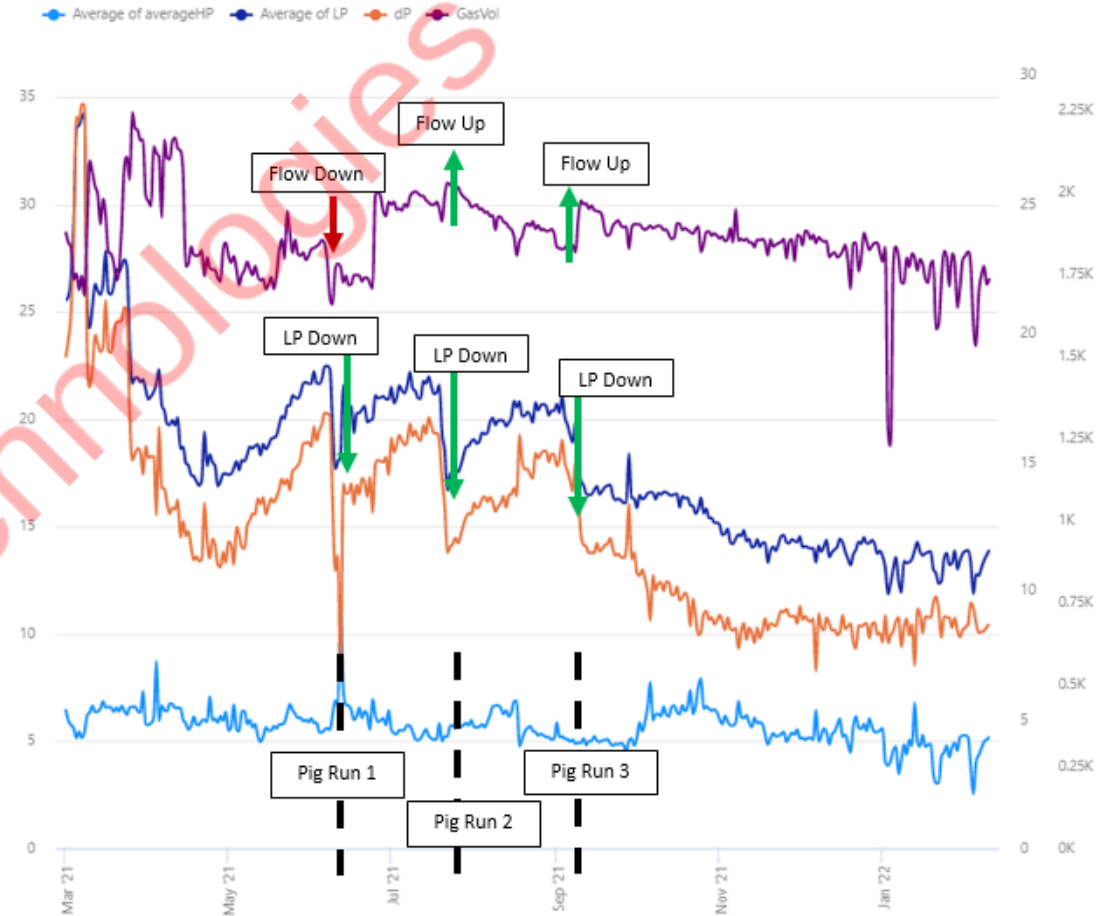
## There is restriction in the pipeline:

- Line pressure negatively correlated to the gas flow. This will cause line pressure to increase and gas flow to decrease.



# Data Points EDA

- A decrease in gas flow with increasing line pressure provides opportunities for the pigging.
- A successful pig run characterized by the restoration of the gas flow and reduction in line pressure in the coming days.
- Currently, with traditional methods, operators observe these data points manually and operate pig runs based on assumptions.





# Primary Trade-offs and Objective

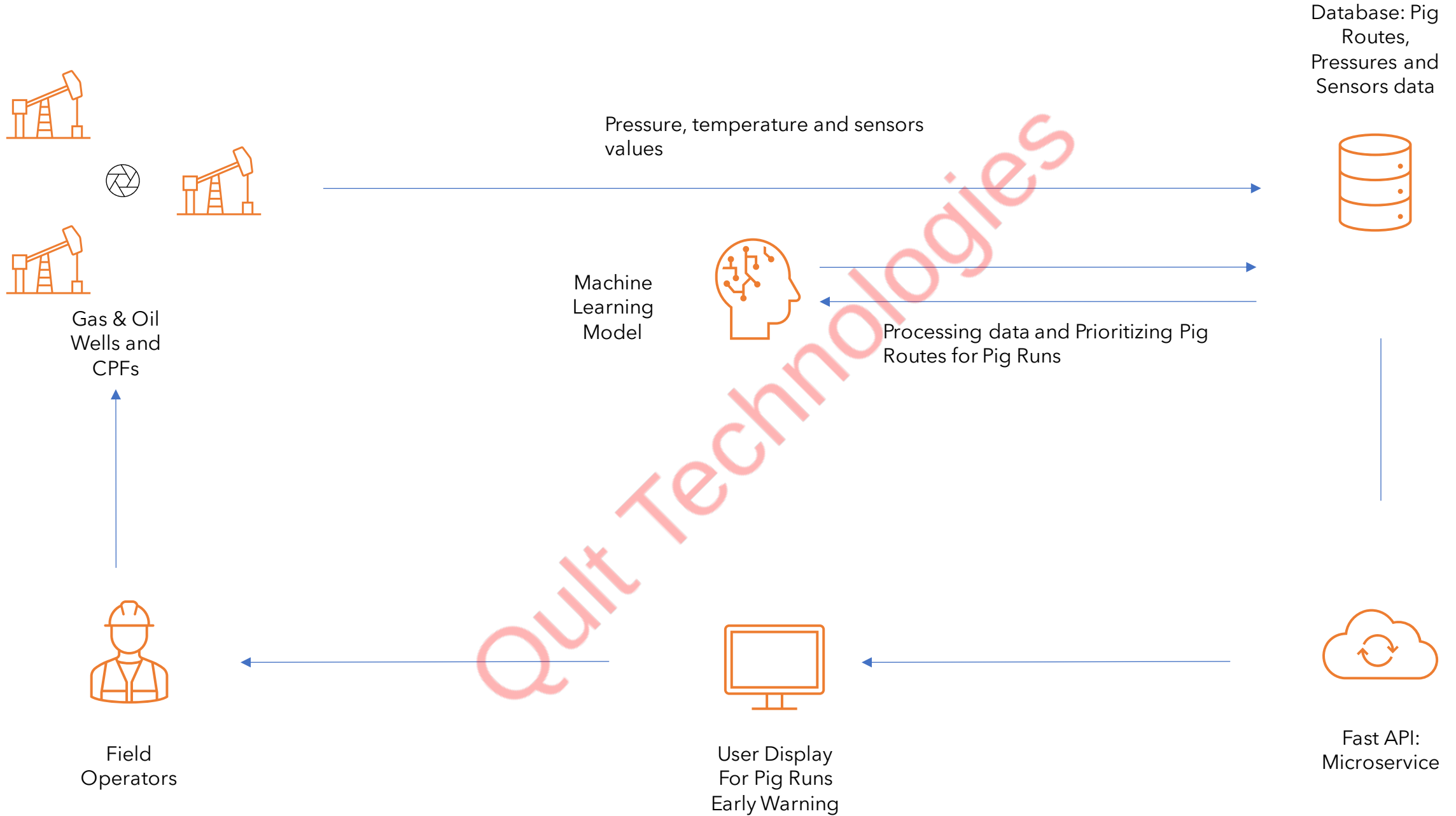
- Detection of opportunities for the pig runs. (Removing liquid or restrictions).
- Prioritizing pig runs as the resource are limited.
- A false positive may cause us 1000\$ in pig material, human resource and impact production from zero to 10,000\$ dollars.

Qult Technologies

# Machine Learning Model for Pig Route Optimization



- Blue bars show confidence in the pig runs for this pig route.
- Red vertical lines are the actual pig runs.
- Line plots are line pressures for the wells attached to this pig route.
- Background processes will calculate these confidence values and provide early warnings for pig runs.
- There will be no need for manual intervention by the operators.



Thank You

Qult Technologies