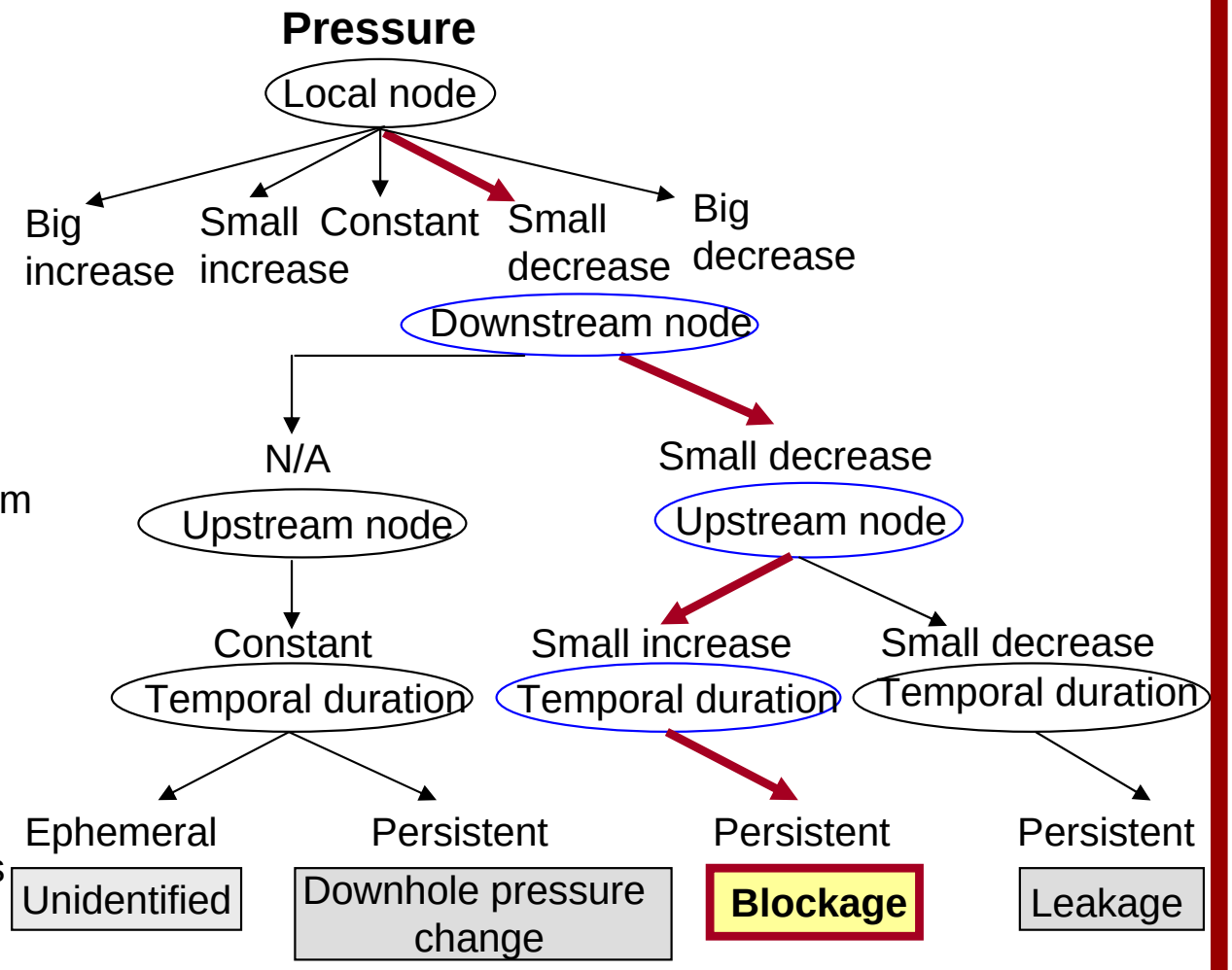
SWATS: Steamflood and **WA**terflood **T**racking **S**ystem

- Problem causes: oilfield engineers care about
  - ***Blockage: primary concern***
  - Leakage
  - Equipment breakdown
  - Outside force/third-party damage
- Problem result: ***out of critical flow rate***
  - Situation where the reduction in the downstream pressure does not increase the upstream mass flow rate
- Goal
  - Create algorithm to detect, identify, and localize the problems reliably, timely, accurately by minimizing false alarms
- Challenges
  - For oilfield engineers
    - Contradictory user requirement: low cost, accurate, timely, fine-granularity, large-area coverage detection
  - For algorithm design
    - Many false alarms to eliminate
    - Unreliable with a single sensor detection

Multi-Modal Multi-Sensor Collaboration to Detect, Identify, and Localize Anomalies

- **Decision Tree**
  - Utilize rule-based problems and false alarm identification by collaboratively exploiting spatial and temporal correlations in the sensor readings
  - Capture the salient pressure and flow characteristics of each problem and distinguish them from false alarms
  - Use static thresholds
- **Multi-modal Multi-sensor Collaboration**
  - Pressure and flow rate at a node
  - Collaboration among upstream, local, and downstream neighbors



An example of decision tree on pressure for blockage, leakage, and downhole pressure change

SWATS: Summary of Major Results

- Simulation
  - Evaluate correctness, timeliness, and robustness of SWATS
    - Domain specific simulator (Dynsim)
    - Ideal and simple topology consists of a single pipeline
    - Realistic setup and parameters
- Verification
  - Identifies and localizes pipeline anomalies fast and correctly
  - Results in a negligible reduction on correctness, timeliness, and robustness with noise in flow
  - Impact of detection threshold on the anomaly severity, latency, and correctness of identification.
    - Smaller detection threshold does not help detect and identify incipient or less severe anomalies -> wrongly decide as false alarms
    - Identification latency (first identification) increases as the detection threshold increases.
    - With threshold greater than 0.01, all the identification reports were correct.
- Show the potential of SWATS algorithm to improve the current SCADA system
  - WSN with inexpensive sensors enables quasi in-situ sensing for pipeline monitoring exploiting spatial and temporal pattern of flow phenomena