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IoT Communication Introduced Limitations for High Sampling Rate Applications

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Motivation & Problem Statement

- IoT and “Smart”-things are trending in various application fields
  - Raise interest from other use cases
  - Different, new application requirements
- Increased challenges for traditional IoT communications
  - Other design assumptions
  - Possible limitations to applications
- Goal here
  - Check applicability of given technologies
  - Show what is possible
  - Raise attention to possible limitations for users / developers

IoT Communications

- Design assumptions
  - Low power
  - Low rate
    - 250 kbps – 802.15.4
  - Many (massive) devices

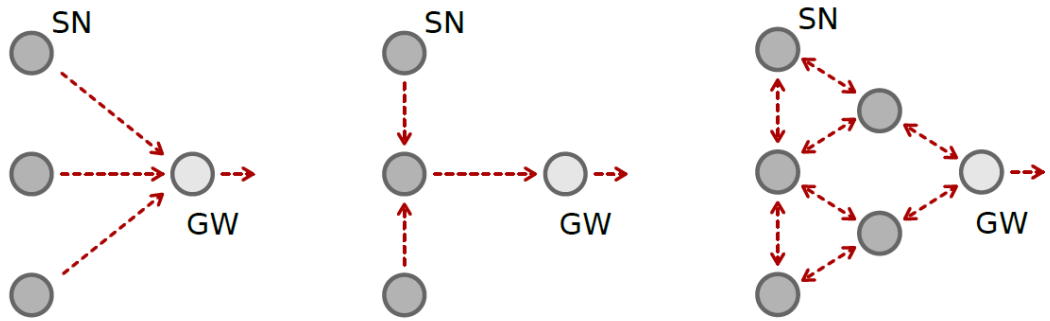
- Example:
  - 6LoWPAN over 802.15.4
  - 250 kbps PHY data rate
  - 127 byte max. raw MAC frame size
    - With 6LoWPAN up to 97 byte user data per frame

Demand for Different Application Patterns

- More challenging applications
  - Increase system / process efficiency
  - “Smart” or “sensing” capabilities as additional feature
- Examples
  - Predictive maintenance
    - Vibrations, pressure
    - Potentially fast-changing parameters
    - High sampling and thus rate
  - Visual monitoring and assessment
    - Capture of imaging data
    - High data amount
- Desired features
  - Node Internet accessibility
    - IPv6-based communication
  - Cloud integration
    - Dashbord visualization
    - Control initiation
      - Eventually AI based
  - Big data analytics
    - Typically not on individual nodes
  - Node cooperation

Challenges & Limitations

- High data amounts to transport
  - Due to
    - High sampling rates
    - Sensors that produce more data
    - Cooperative applications
  - Technology design goals different
    - Still applicable?
    - Where are limits?
  - Challenges
    - Available bandwidth & utilization



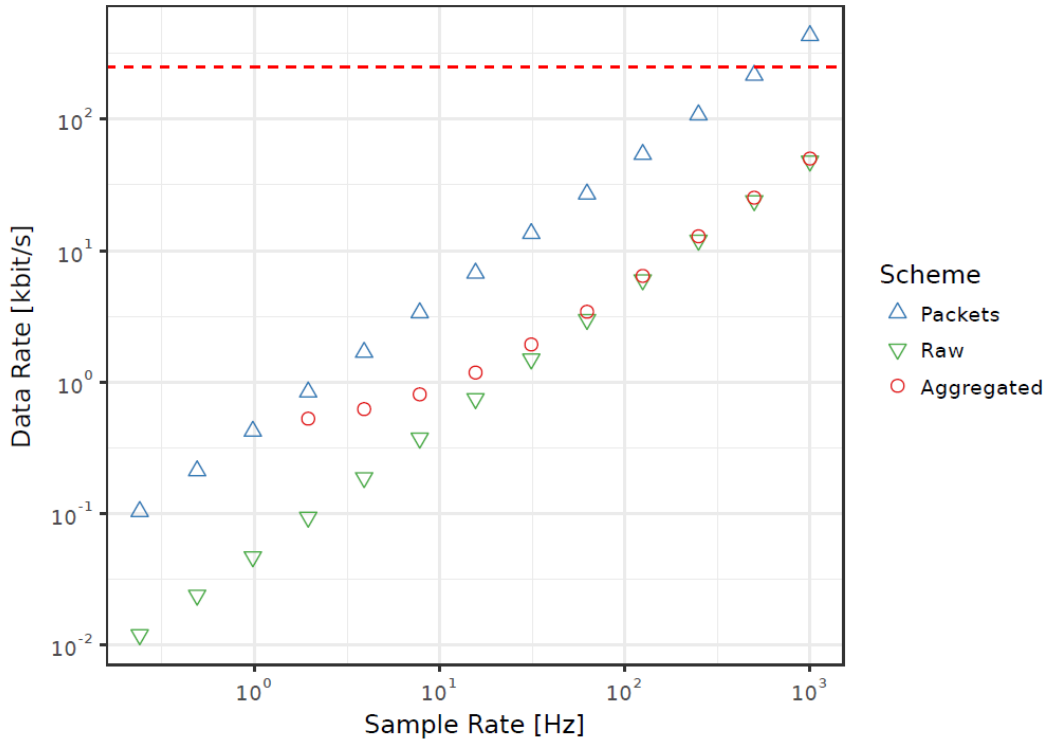
(a) Star (b) Relay (c) Cooperative

Example – 6LoWPAN & High Sampling Rate Application

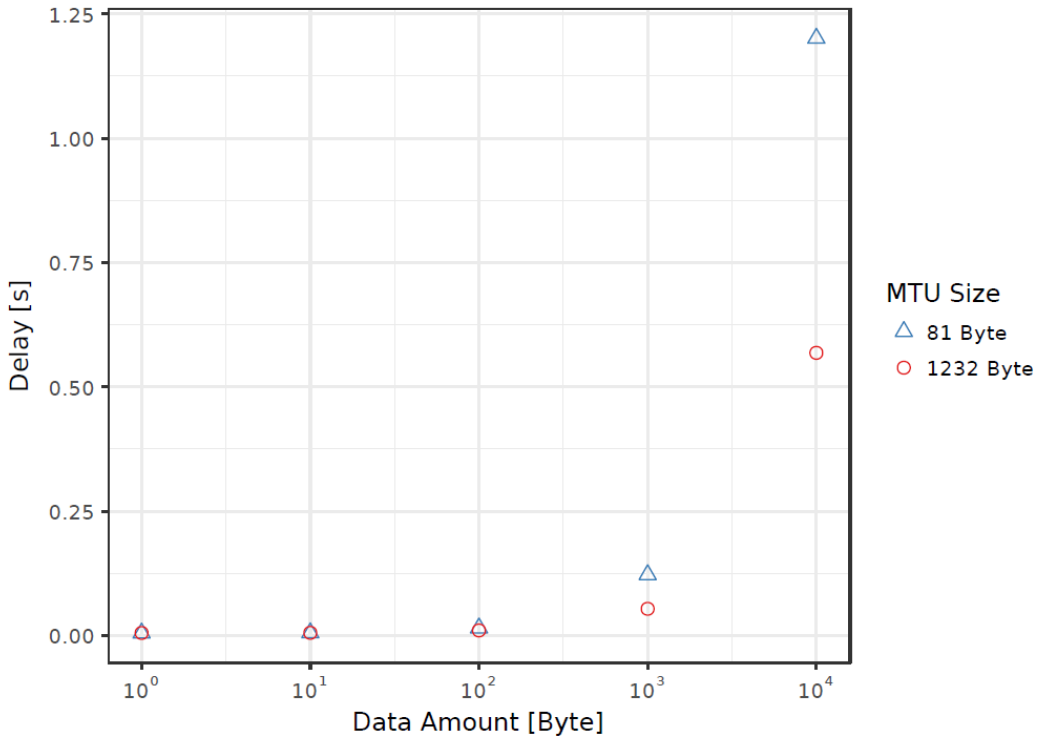
- Vibration Monitoring Application
  - High sampling rates > 100 Hz desired
  - Distributed observation at multiple measurement points
- Why transfer all data?
  - Initial process characterization
    - Detect all possible events
  - Uncover correlations between neighboring measurement points
  - Later tuning also possible
- Vibration Sensor with High Sample Rate
  - MPU 9250 – 9 DOF motion senor
    - 3 axes
    - 16 bit sample each
    - 6 byte per complete sample
    - 0.25 – 1000 Hz sampling frequency
- 6LoWPAN communication
  - IPv6
  - 802.15.4 as base technology

Results

Theoretical Performance



Measured Throughput



Lessons Learned

Scientific Perspective

- 6LoWPAN has much overhead
  - But required for IP-based communication
  - Limitations exist but can be handled
- Data aggregation to mitigate effect
  - Time dependent applicability
- Further analysis for high rate applications

Developer Perspective

- Stack implementation and config crucial
  - Allow effective utilization of resources
- Balance application needs and local network load
  - Consider network capabilities in application development

Alternatives

- In-Node Processing
  - Data reduction through
    - Filtering (Thresholds, Differences)
    - Event Detection
      - Unknown events or initial process observation ?
  - Tradeoff for processing effort
    - Time and energy
  - How to capture correlated metrics with neighbors if data is filtered ?
- Alternative Communication Technologies
  - BLE ?
  - WiFi ?
  - Cellular ?

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Conclusions

- New application fields want to benefit from “smart” sensing and Internet connectivity
  - Contrary requirements to original design goals
  - Energy-efficient operation of nodes
- Balance between application and network load needed
- Discussion on other traffic requirements and realization

Thanks for your attention. Questions?

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