

Exploiting Platform Heterogeneity in Wireless Sensor Networks for Cooperative Data Processing



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Image source: www.dreamstime.com



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Outline

Traffic Characteristics in Wireless Sensor Networks

- Problem statement

Benefits of Platform Heterogeneity

- Comparison of current mote platforms
- Analysis of their energy consumptions

Exemplary Application Scenarios for Heterogeneous WSNs

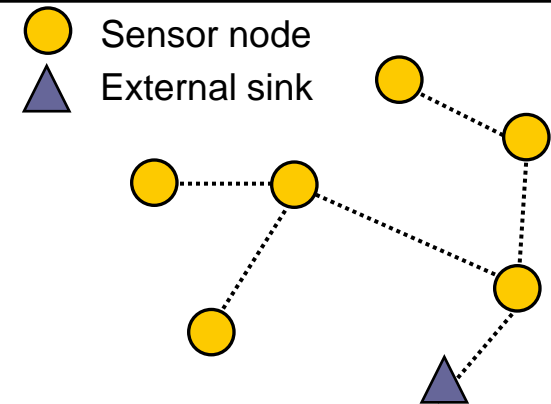
- Data compression
- Cryptographic operations
- High data rate sample processing

Summary and Outlook

Sensor Network Characteristics

General Traffic Characteristics

- Limited number of connections
 - Network management – to immediate neighbors
 - Data transport – to sink node
- WSNs are often organized in a convergecast manner
 - All sensor data is routed to the sink

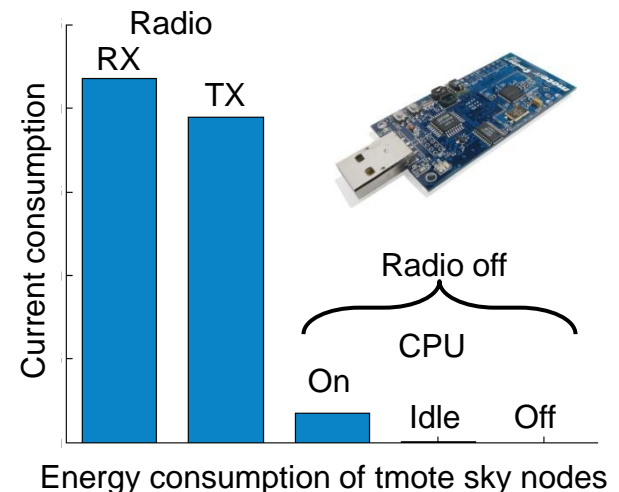


Energy is a crucial aspect in WSNs...

- Battery charge limits node and network lifetime

...but radio operation is expensive

- CC2420 radio transceiver
 - RX: 19.7 mA, TX: 17.4mA, off: 1 μ A
- MSP430 microcontroller
 - on: 0.33mA, idle: 1.9 μ A, off: 0.2 μ A

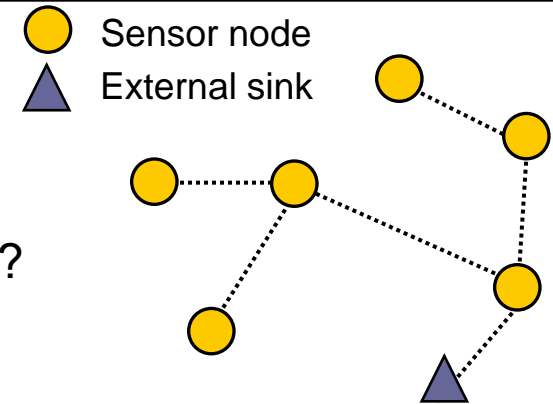


Problem Statement

Local and/or in-network data processing

- Perform operations on the sensor data
 - Averaging, min/max, basic compression...
 - But are more complex operations (FFT, ...) feasible?
- Limited due to mote hardware constraints
 - Low computational power
 - Available memory (RAM / Flash)
 - Cost
- Data processed at external sink node instead
 - Necessitating (multi-hop) radio transmissions

} desired properties for long battery lifetime



Find means to shift processing tasks into the WSN

- At an overall saving in energy consumption

Integrate (computationally) heterogeneous mote platforms

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Benefits of Platform Heterogeneity (I)

Comparison of current mote platforms



	Mica2	TelosB	SunSPOT	Imote2
RAM size	4 kB	10 kB	512 kB	32 MB
System clock	7.37 MHz	8 MHz	180 MHz	104 MHz*
Word size	8 bits	16 bits	32 bits	32 bits

* The Imote2 can dynamically scale its frequency from 4 – 416 MHz

Significant differences in system clock and RAM size

- Mica2 and TelosB well suited for sensing and simple processing
- SunSPOT and Imote2 well suited for processing tasks

Does deploying dedicated processing nodes make sense?

Benefits of Platform Heterogeneity (II)



Energy consumptions in sleep and active mode

	Mica2	TelosB	SunSPOT	Imote2
Sleep current	15 μ A	1 μ A	31 μ A	820 μ A
Active current	8 mA	1.8 mA	80 mA	66 mA
Word size	8 bits	16 bits	32 bits	32 bits

Energy consumptions by processor platforms significantly higher

- BUT: Higher clock speed leads to shorter duty cycles
- Comparison of the energy demand for a function of 100,000 instructions:

	Mica2	TelosB	SunSPOT	Imote2
Execution time	13.6 ms	12.5 ms	0.55 ms	0.96 ms
Energy per call	327 μ J	67.6 μ J	82.7 μ J	98.4 μ J
Average power	3.3 mW	0.68 mW	0.85 mW	1.37 mW

Power consumption of TelosB and SunSPOT very close

- Emulation overhead when executing 32 bit operations on 16 bit microcontroller

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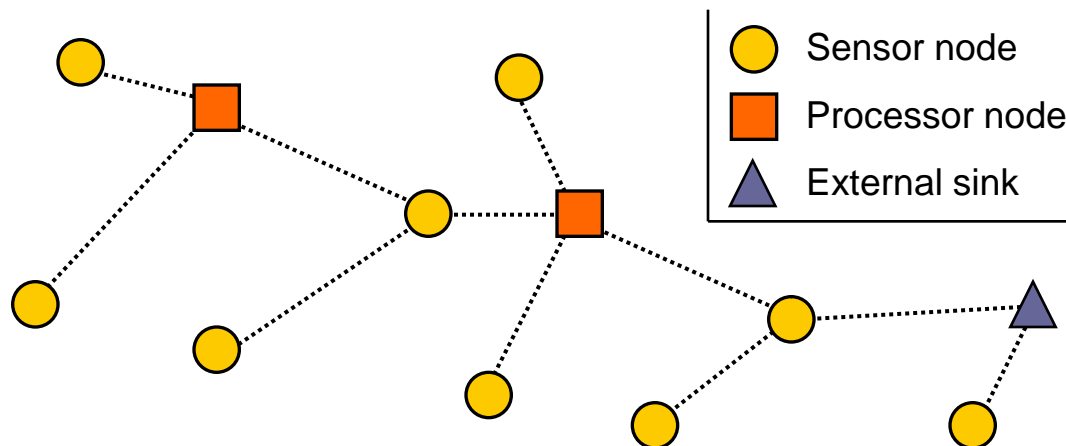
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Summary and Outlook

Exemplary Application Scenarios

Data compression

- Compress results of in-network aggregation
- Allow for more sophisticated compression algorithms



Cryptographic operations

- Often, motes are incapable of performing strong cryptographic operations
- Form “clouds of trust” around processor nodes
- Only encrypted data may leave the cloud

High data rate signal processing

- Processor nodes can extract features inside the network
- Significant reduction of traffic to the sink

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Summary and Outlook

Summary and Outlook

Heterogeneous wireless sensor networks

- Integration of processing nodes into the WSN
 - More processing power
 - Greater amounts of memory
- Power consumption is similar to motes for equal application sizes
- Amount of multi-hop convergecast radio traffic can be reduced

Heterogeneous sensor networks are a viable way to save energy

Outlook

- Improve energy model of sensor nodes
- Investigate partitioning algorithms
 - Which amount of data to process locally, which amount to forward?
- Perform simulations using tmote sky and SunSPOT nodes
- Verify findings using a real testbed

Thank You for Your Attention!



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