XDense: A Dense Grid Sensor Network for Distributed Feature Extraction

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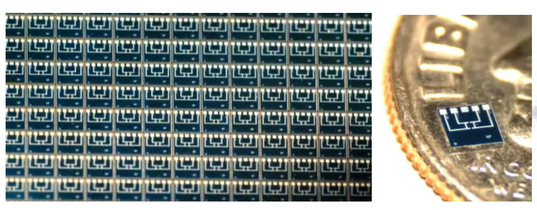
Motivation

Development of a sensor network architecture tailored for high sampling rate applications and high density of sensor node deployments

Application example: Active Flow Control (AFC)



Hot wire shear stress sensor from FCAAP[2]

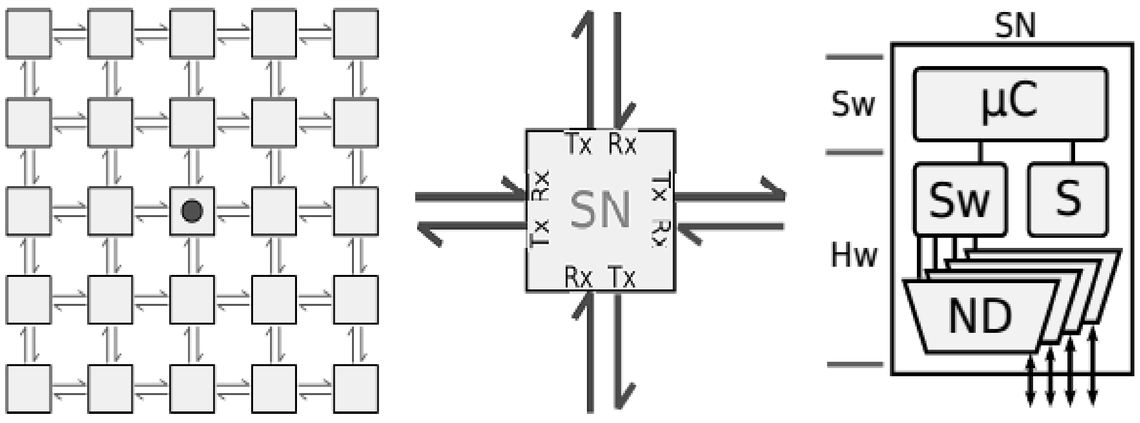
WICAS [1]

- Scales of **100 µm** for the sensor size and its interspaccing;
- Sampling rates of **100 kHz** or more
- Large number of sensors required for capturing the phenomena.

Objectives and System Architecture

Objectives

- Investigate architectural and communication issues for a large-scale dense sensor network, addressing issues like network topology, medium access control, routing and in-network data processing.
- Design of distributed processing strategies for detecting events with low latency which is essential to meet the requirements of RT control systems.



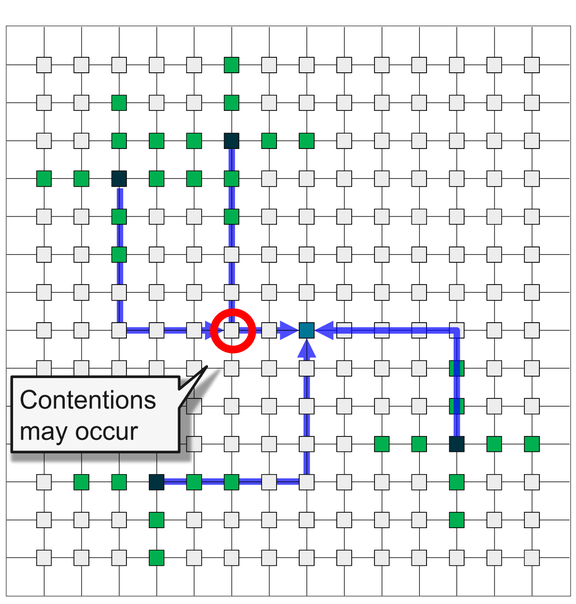
- Mesh grid sensor network: Local data exchange and processing enables complex feature detection, and reporting of pre-processed data;
- The growth of the network does not impact significantly on the overall latency. Can scale up to any size, limited only by the minimum of one sink on each node's address space

3 state principle of operation:

1st Network Discovery
Each node discovers its neighborhors and the closest path to the sink(s)

2nd Event Monitoring
Communicate sensed values with their n-hops. (Ex: in figure n = 2)

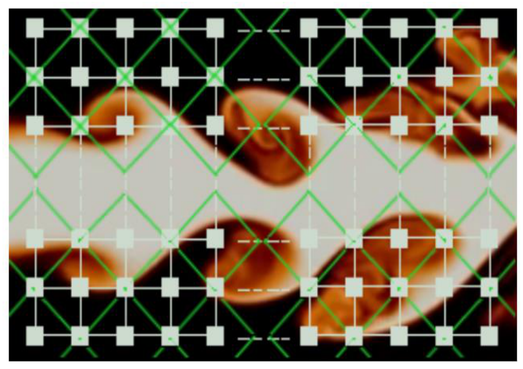
3rd Event Announcement
Data is sent to the sink by the nodes who detected any feature.



Building XDense

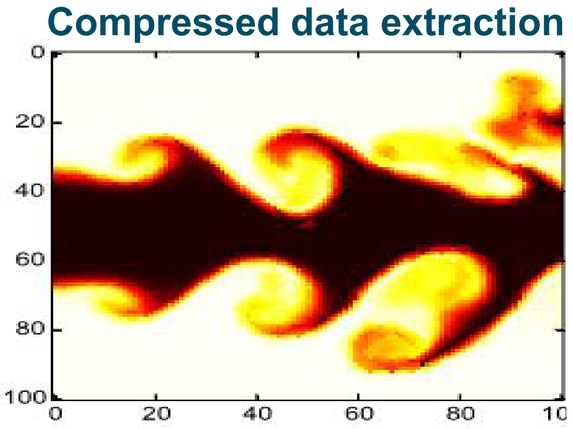
Simulation Results

A network of 101x101 nodes and one sink is superimposed in a fluid dynamic scenario.



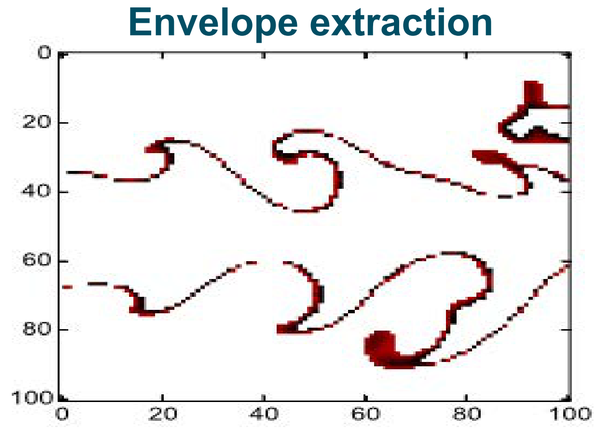
A planar free air jet from a CFD is utilized as the input of our sensor nodes. We peform:

Compressed data extraction



Takes 20% of the total time required to read all the nodes

Envelope extraction



Takes 8% of the total time required to read all the nodes

Implemention with COTS

We use Atmel ATSAM4N8A uC (ARM Cortex M4@100MHz)

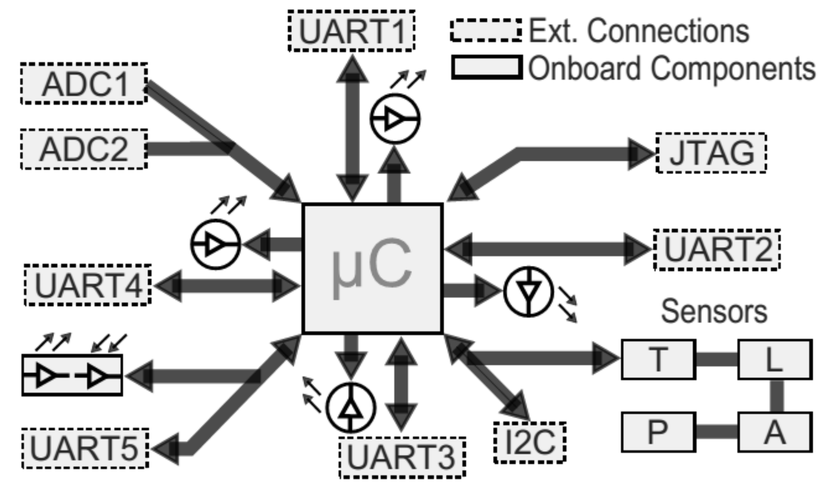
It has 5 UARTS and 23 DMA channels in a 48 pins package

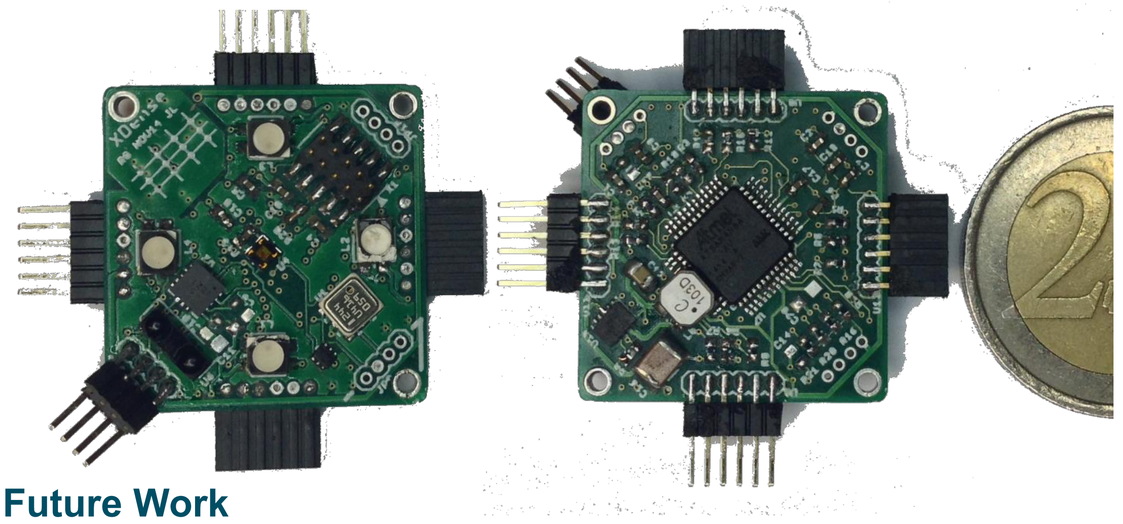
For sensing:

- Luminosity
- Accelerometer
- Temperature
- Pressure

For acting:

- 4 RGD LEDs





Future Work

Examine the significance and efficacy of this approach by exploring aspects like routing, flow control and distributed data processing and aggregation.

References

[1] Wireless Interconnectivity and Control of Active Systems Website (WICAS), http://www.shef.ac.uk/systemsutc/projects/wicas
[2] FCAAP. Florida Center for Advanced Aero-Propulsion

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