XDense: A Sensor Network for Extreme Dense Sensing

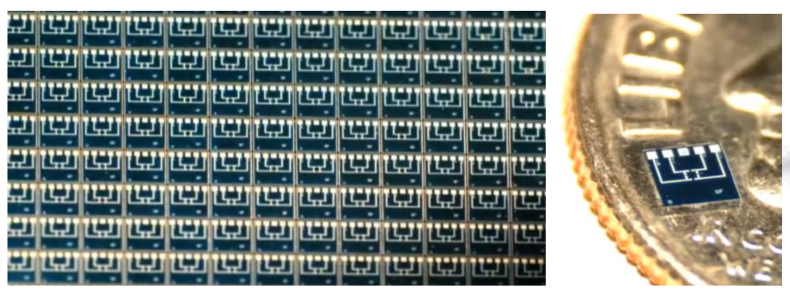
CISTER - Research Center in
Real-Time & Embedded Computing Systems

João Loureiro, Vikram Gupta, Nuno Pereira,
Eduardo Tovar, Raghuraman Rangarajan
{joflo, vigup, nap, emt, raghu}@isep.ipp.pt

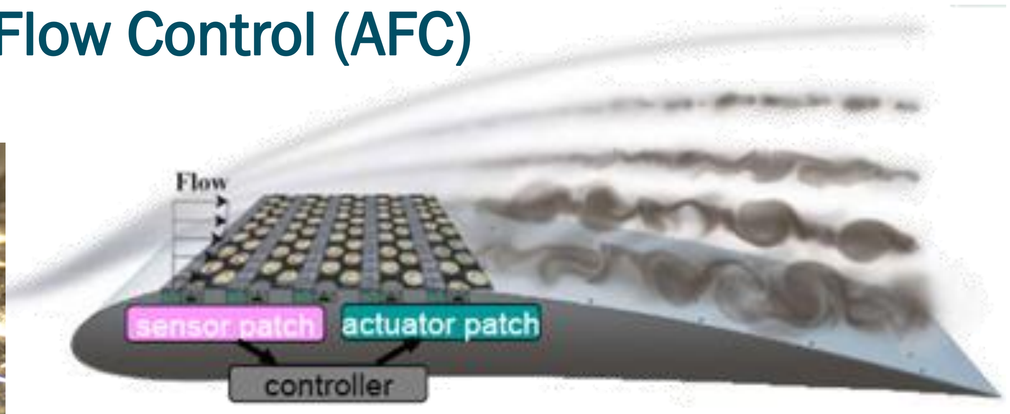
Motivation

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

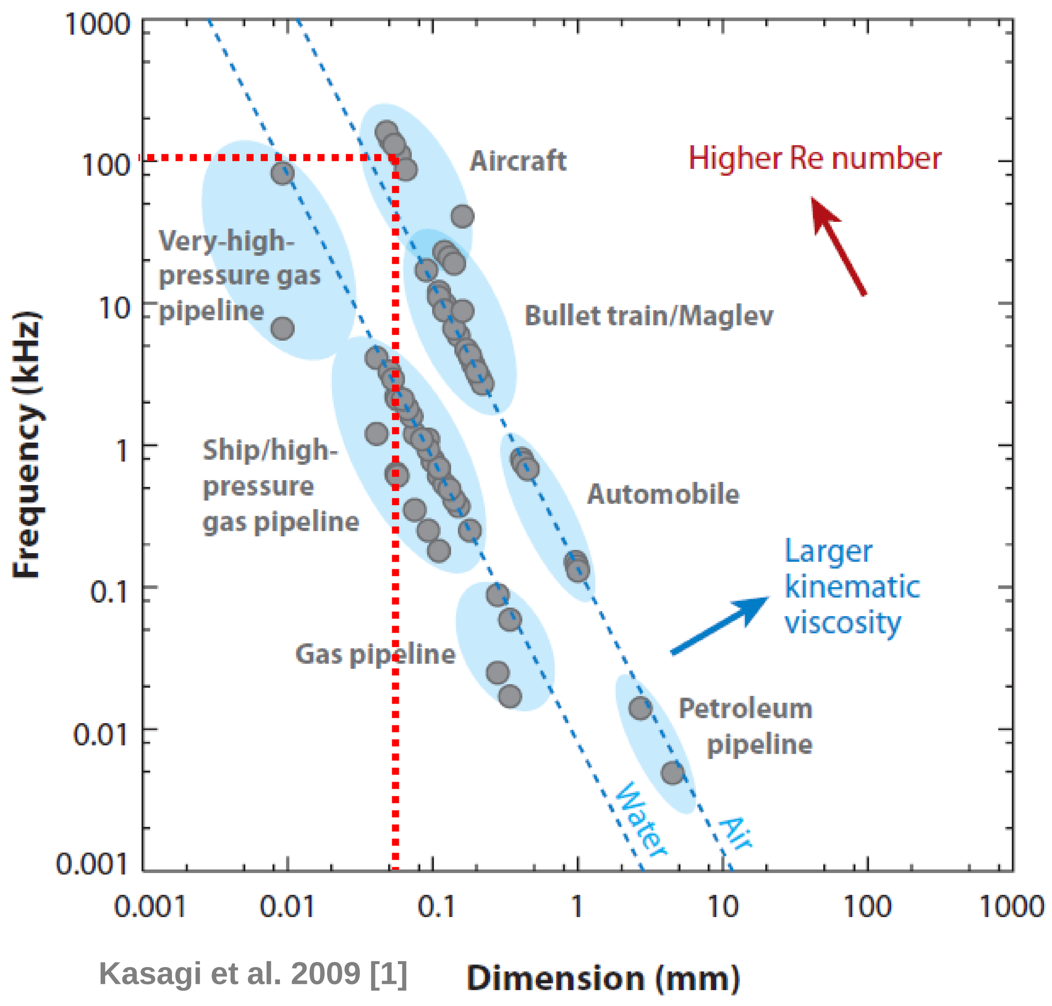
Application example: Active Flow Control (AFC)



Hot wire shear stress sensor from FCAAP[3]



WICAS [2]



Scales of **100 μm** for the sensor size and its interspaccing

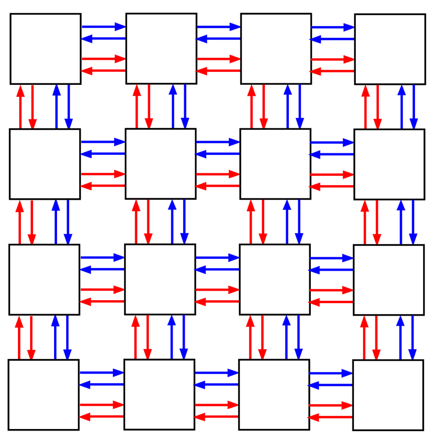
Sampling rates of **100 kHz** or more

Large number of sensors required for capturing the phenomena.

Objectives and System Architecture

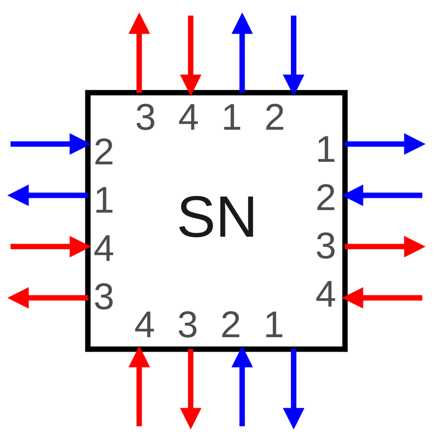
Objectives

- 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.



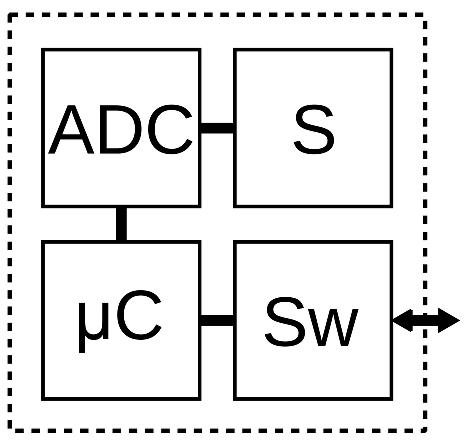
2D mesh sensor network:

- Distributed event detection, without the need of central data aquisition and processing;
- Regular structures resembles the architecture of a NoC.



Node Pinout:

- Full duplex serial ports: input and output data pins
- Handshaking: input and output control pins



Node architecture

- Consists of one switch and one microcontroller connected to the sensor through one ADC.

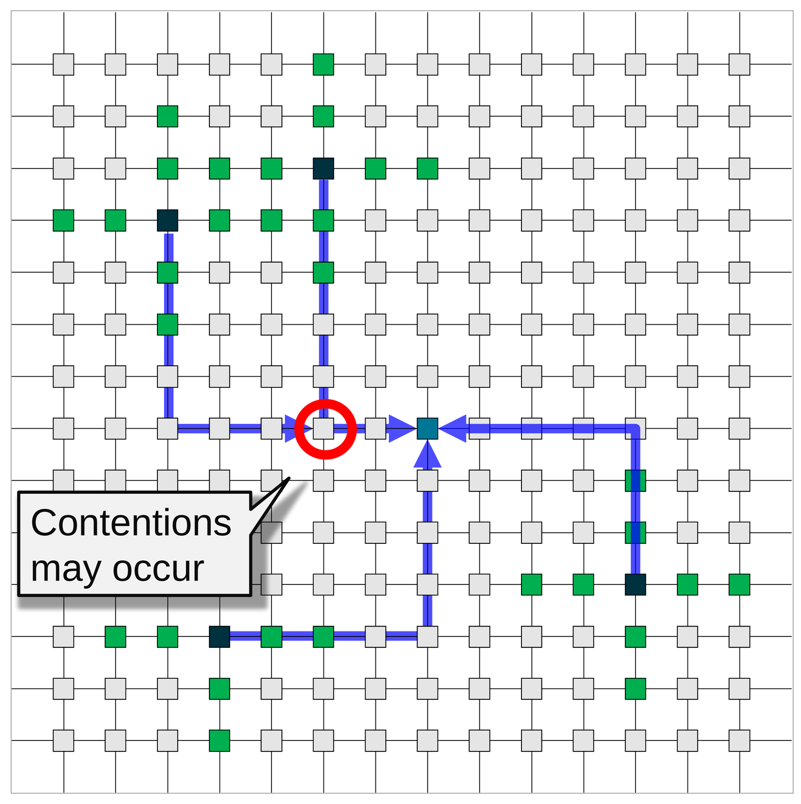
Preliminary Results and Future Work

The principle of operation is based in 3 different states:

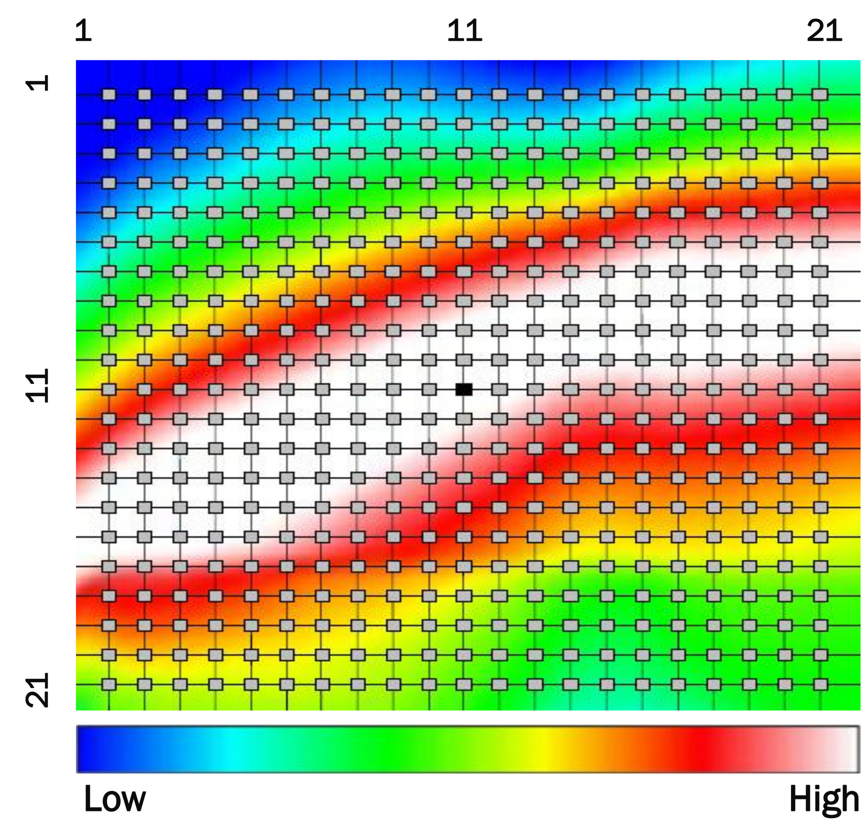
1st Network Discovery
Each node discovers its neighborhors and the closest path to the sink(s)

2nd Event Monitoring
Sense the environment and communicate the values with their n-hops. (Ex: in figure n = 2)

3rd Event Announcement
A connection path to the sink is established and data is sent by the nodes who detected any event.



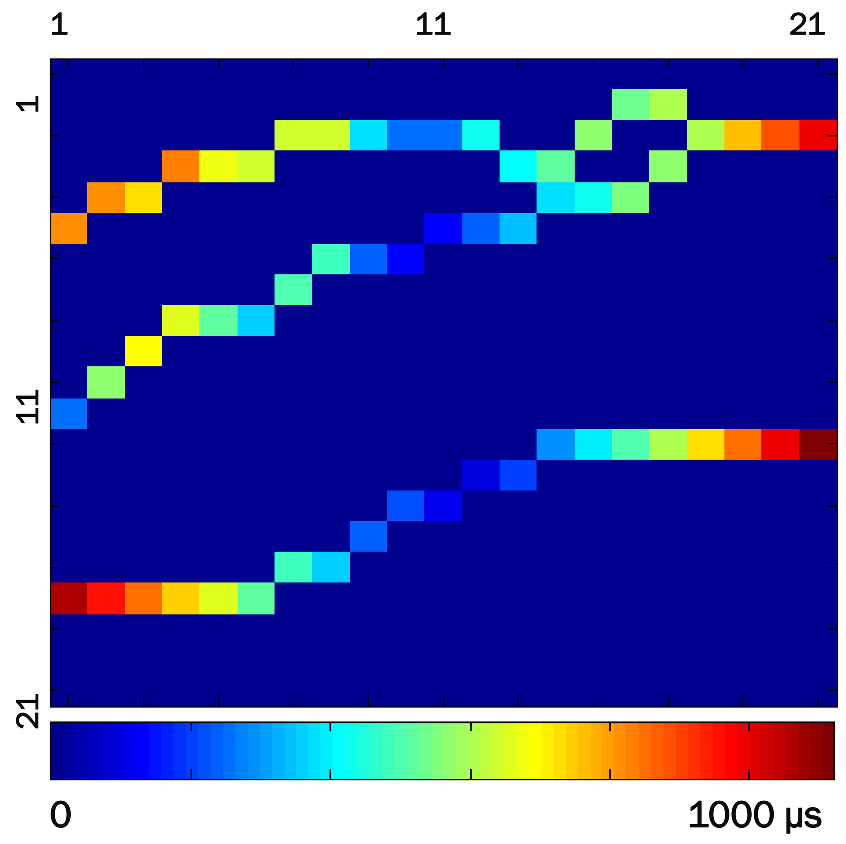
Simulation Scenario



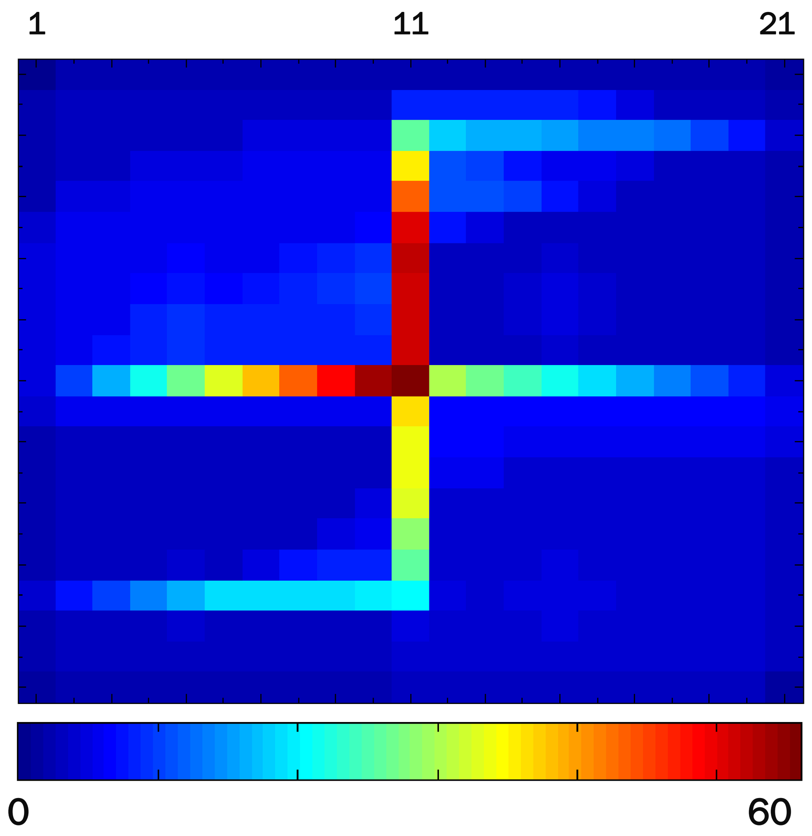
- Grid of 21 x 21 nodes, with one sink in center
- Grid is superimposed on a pressure distribution snapshot
- Neighborhood size is two (n = 2)

✓ Only 13% of the nodes transmitted
✓ Information enough to provide an accurate picture of phenomenon with low latency

Nodes Latency



Packets Transmited per Node



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] Nobuhide Kasagi, Yuji Suzuki, and Koji Fukagata. Microelectromechanical systems-based feedback control of turbulence for skin friction reduction. Annual review of fluid mechanics, 41:231–251, 2009.
[2] Wireless Interconnectivity and Control of Active Systems Website (WICAS), http://www.shef.ac.uk/systemsutc/projects/wicas
[3] FCAAP. Florida Center for Advanced Aero-Propulsion

Projects:
FCOMP-01-0124-FEDER-037281 (CISTER);
FCOMP-01-0124-FEDER-020312 (SMARTSKIN);
FCOMP-01-0124-FEDER-012988 (SENODS);
FCOMP-01-0124-FEDER-028990 (PATTERN).
Co-financed by:

CISTER Research Centre/INESC-TEC
ISEP, Polytechnic Institute of Porto
Rua Dr. Antº Bernardino de Almeida, 431
4200-072 PORTO Portugal
tel: +351-228340502
fax: +351-228340509
http://www.cister.isep.ipp.pt
cister-info@isep.ipp.pt