A Reputation and Trust Based Multi-Modal Sensor Network for Environmental Monitoring

Edel O'Connor

Prof. Alan F. Smeaton, Prof. Noel E. O'Connor & Prof. Dermot Diamond

This Beaufort Marine Research Award is carried out under the *Sea Change* Strategy and the Strategy for Science Technology and Innovation (2006-2013), with the support of the Marine Institute, funded under the Marine Research Sub-Programme of the National Development Plan 2007–2013.

Presentation Outline

- Water management and issues with in-situ WSNs.
- Multi-modal sensor networks
- Data Aggregation
- Pilot studies
  - River Lee water depth study
  - Water level prediction for adaptive sampling
- Trust and reputation framework

Water Management

- Water management is an important part of the monitoring of the natural environment.
- For many years water managers relied on field measurements for coastal monitoring and water quality evaluation.
- However this process is being revolutionised through the introduction of new technologies such as sensor networks


Image: John Cleary

Issues

- Current state of the art in **chemo/bio-sensor networks** not at a stage for reliable long-term large scale deployment.
- Even without the complexity of chemo-bio sensing, still considerable issues
  - Sensors subject to **harsh conditions**
  - **Bio-fouling**
  - Limited **spatial resolution**
  - Difficult to **monitor large areas** over long periods of time
  - **Unsuitable for certain environments** and the immediate detection of certain events
  - Developments in sensor research **pushing towards ever cheaper systems**
  - Huge **information overload** – user requires reliable event detection.

Image: www.ferrybox.eu/imperia/md/images/ferryboxuse

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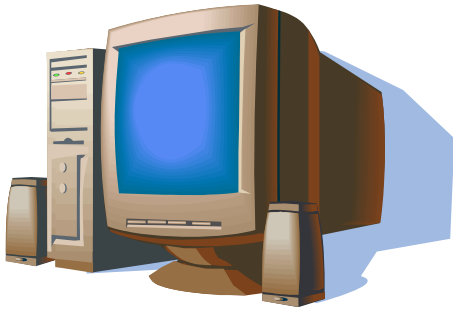
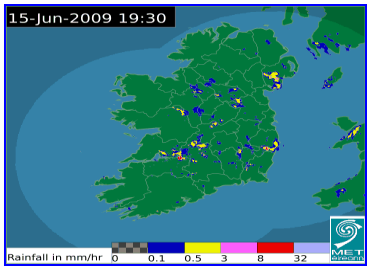
Multi-modal sensor networks

- The incorporation of alternative sensing modalities such as visual sensors, alongside an in-situ WSN can help to overcome some of these problems.

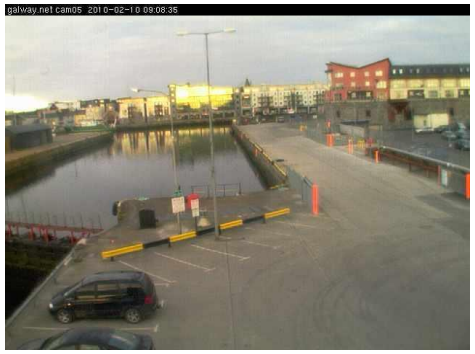




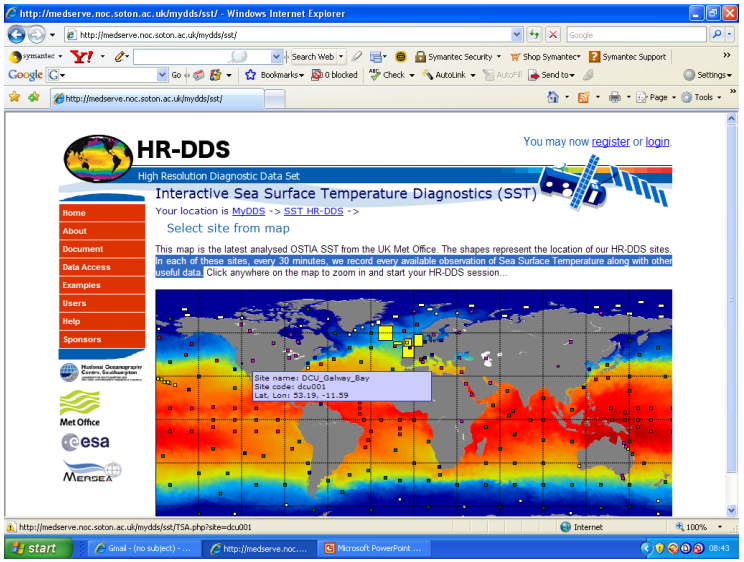
Test Sites

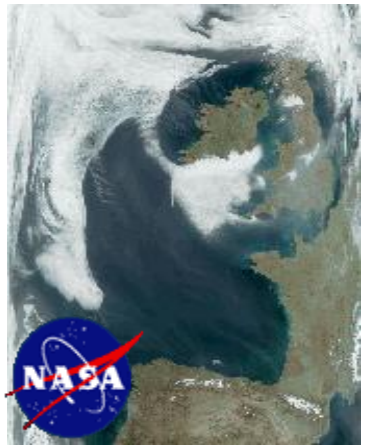
Requirements	River Lee	Galway Bay	River Tolka
Network	x	x	
Power	x	x	
Security	x	x	
Multiple sensing modalities	x	x	
Interesting from marine perspective	x	x	x

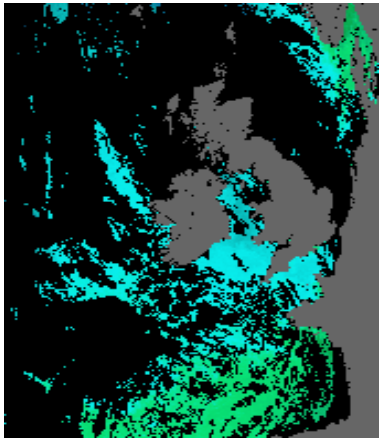
Data Aggregation – Camera data

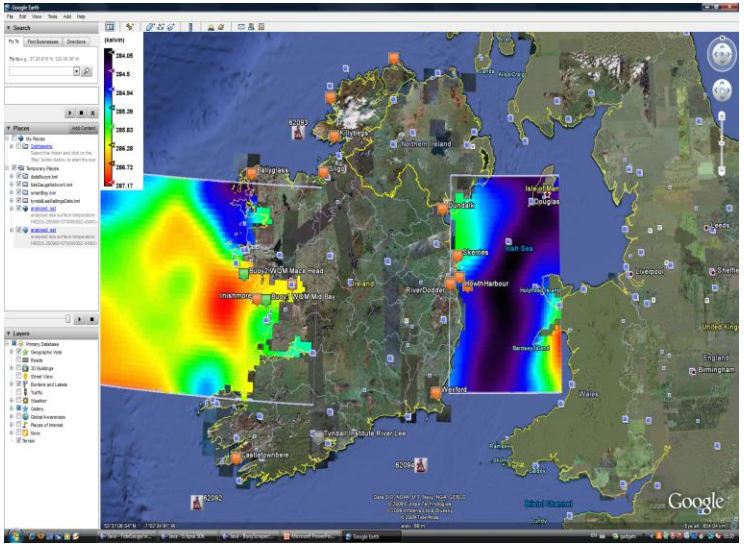


Data Aggregation – Satellite data









In-situ sensor data and context data

Deploy: River Lee

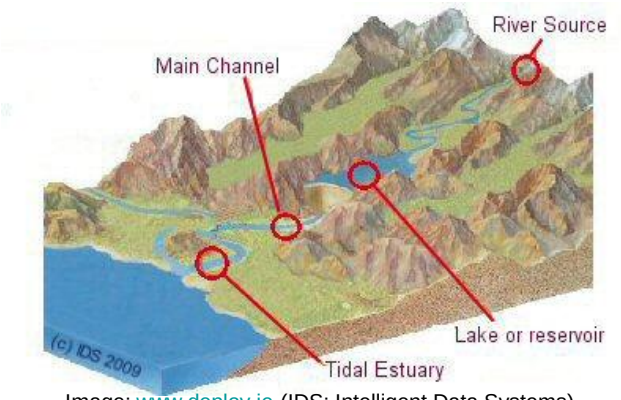
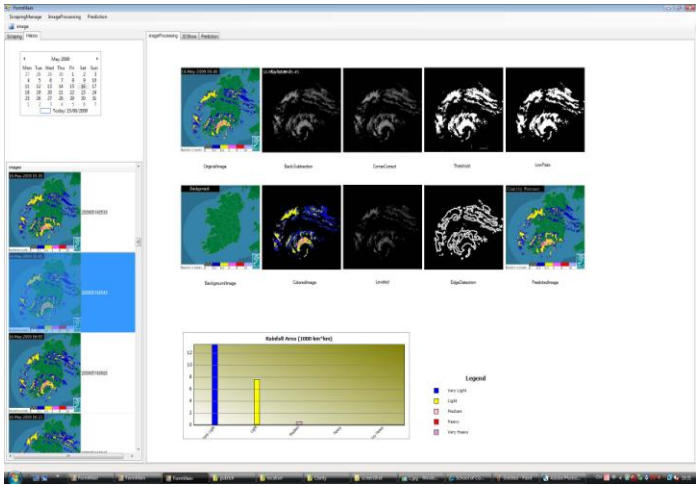


Image: www.deploy.ie (IDS: Intelligent Data Systems)

Rainfall Radar processing



SmartBay: Galway Bay

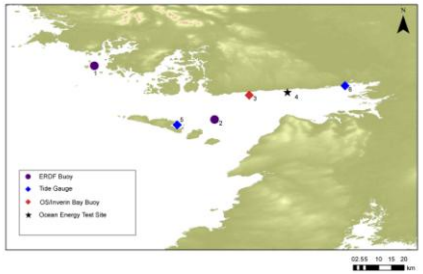
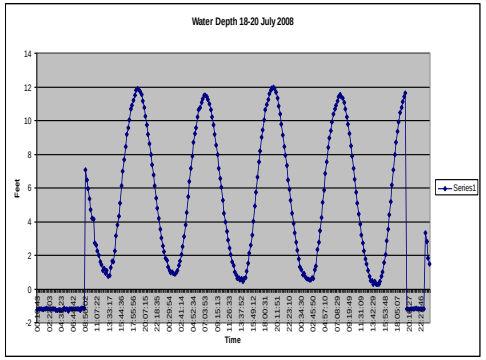
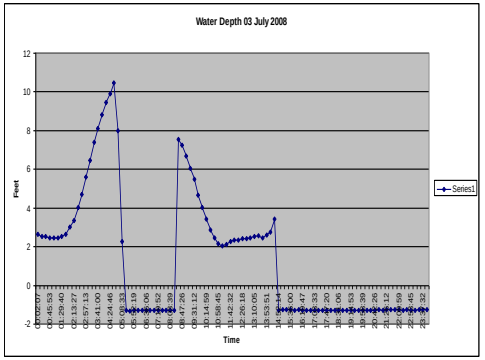
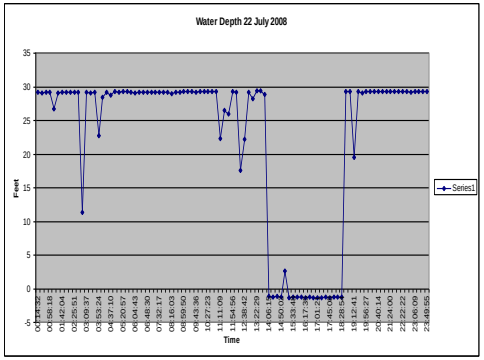


Image: Marine Institute

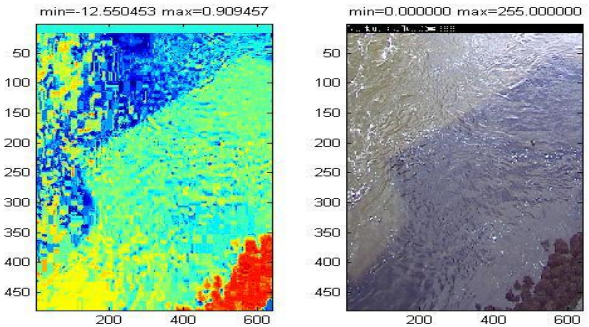
River Lee Water Depth Study







	C_1	C_2	C_3
Class Distance Error	0.642	0.537	0.302
Classification Rate	0.467	0.732	0.750



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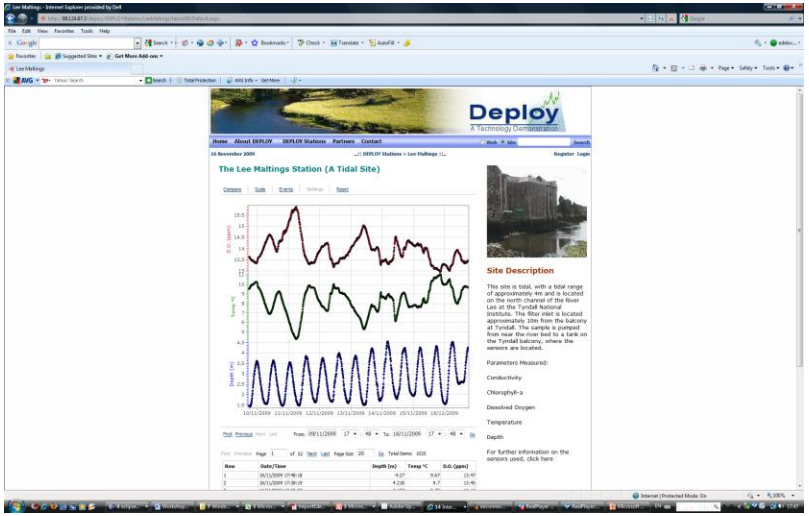
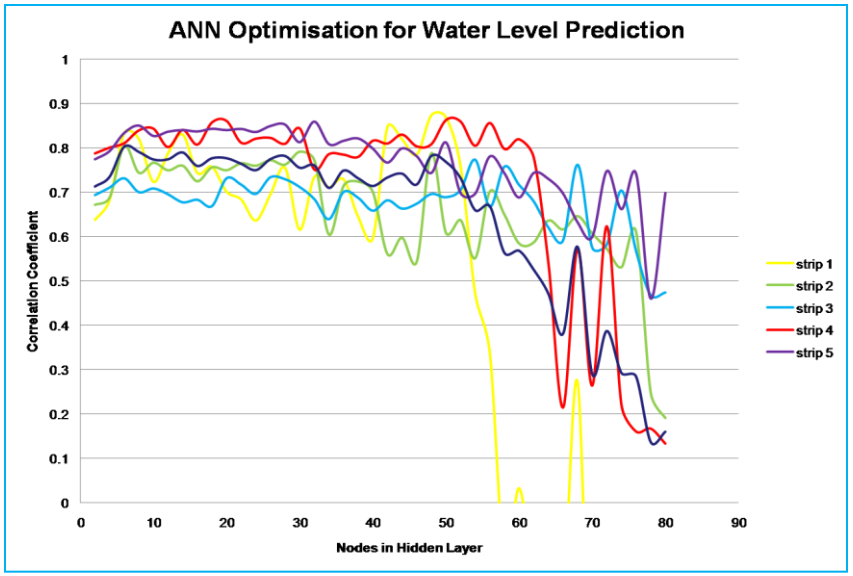
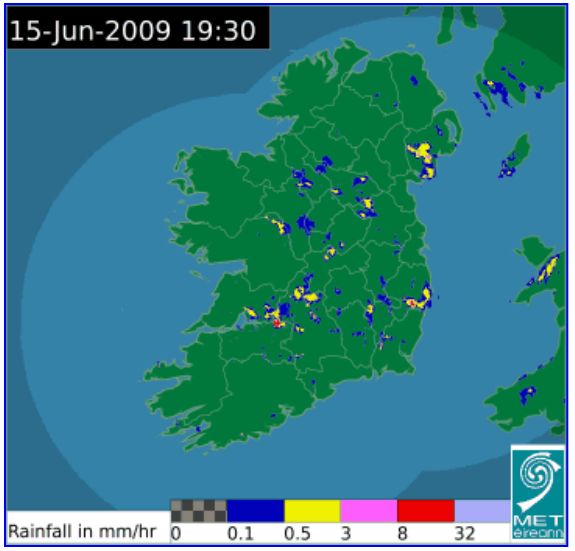
Multi-modal sensor networks – adaptive sampling

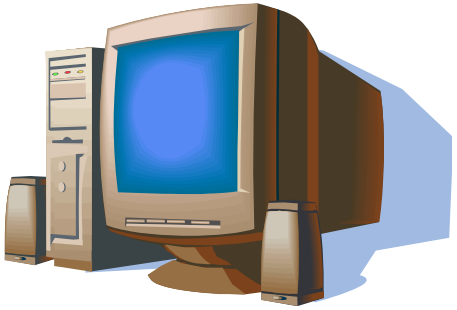


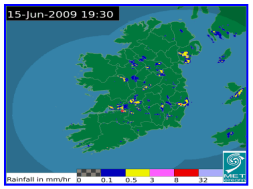




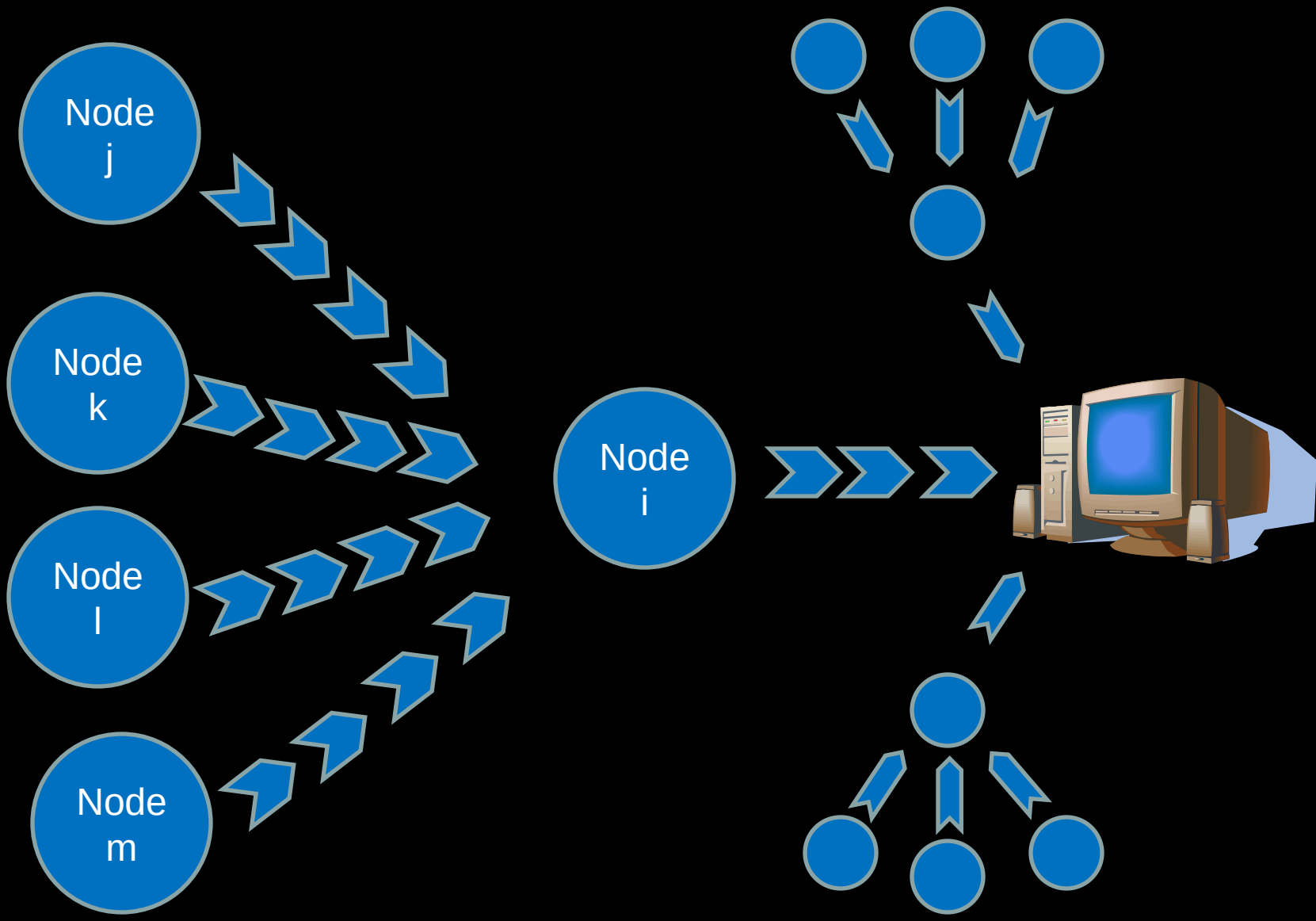
Reputation and Trust-based multi-modal sensor network

- Development of a reputation and trust-based multi-modal sensor network
- Adaptation of a model developed for in – situ sensor networks known as RFSN (RFSN Ganeriwal & Srivistava 2008).
- Adaption of this model to multi-modal sensor networks





Community of Sensor Nodes



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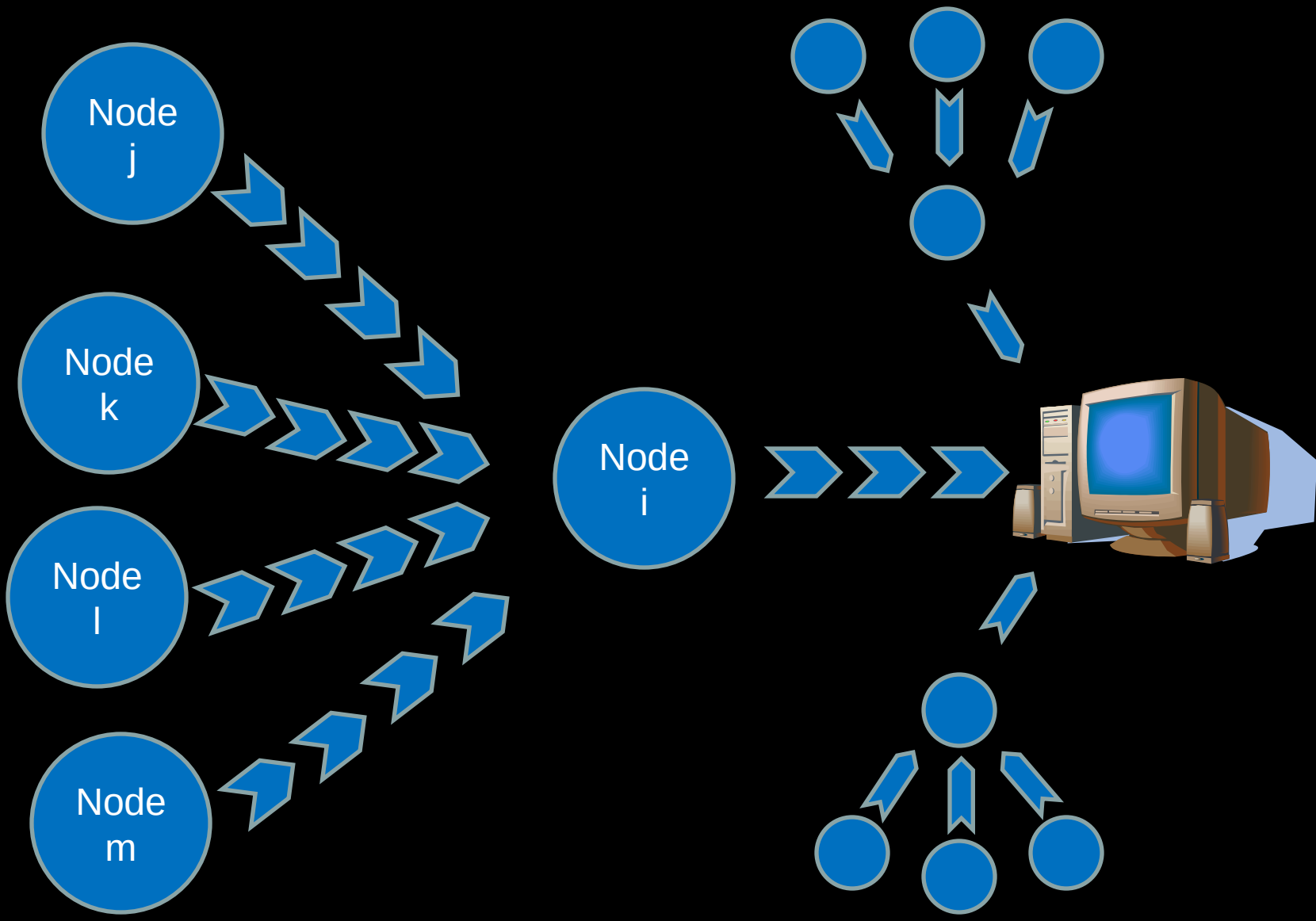
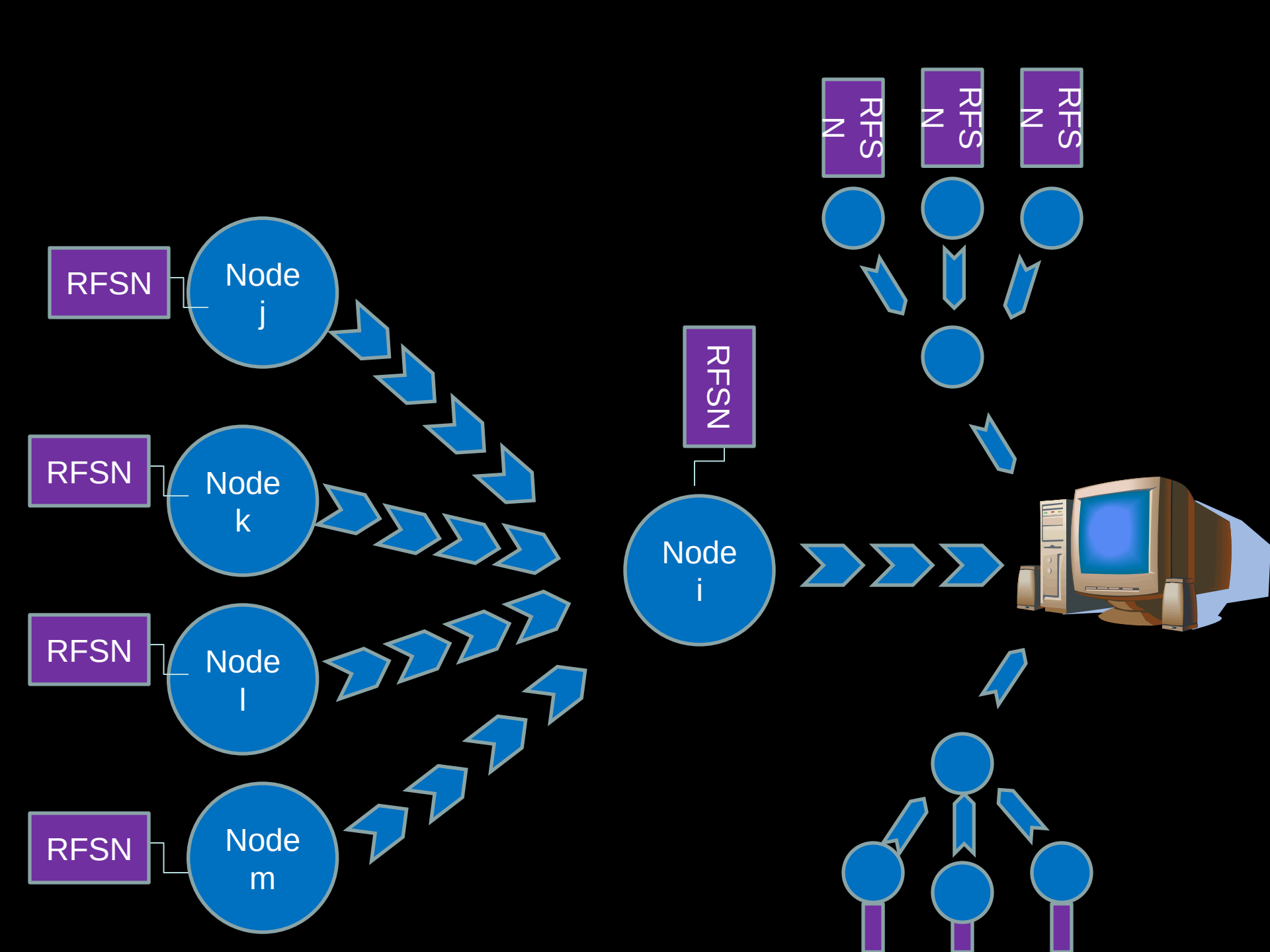



RFSN
Node j
RFSN
Node k
RFSN
Node l
RFSN
Node m
RFSN
Node i
RFSN
RFSN
RFSN

Community of Sensor Nodes

RFSN

[j,k,l,m]

WATCHDOG

Series of outlier detection protocols, outputs cooperation metrics for each of the nodes.

Cooperation metrics

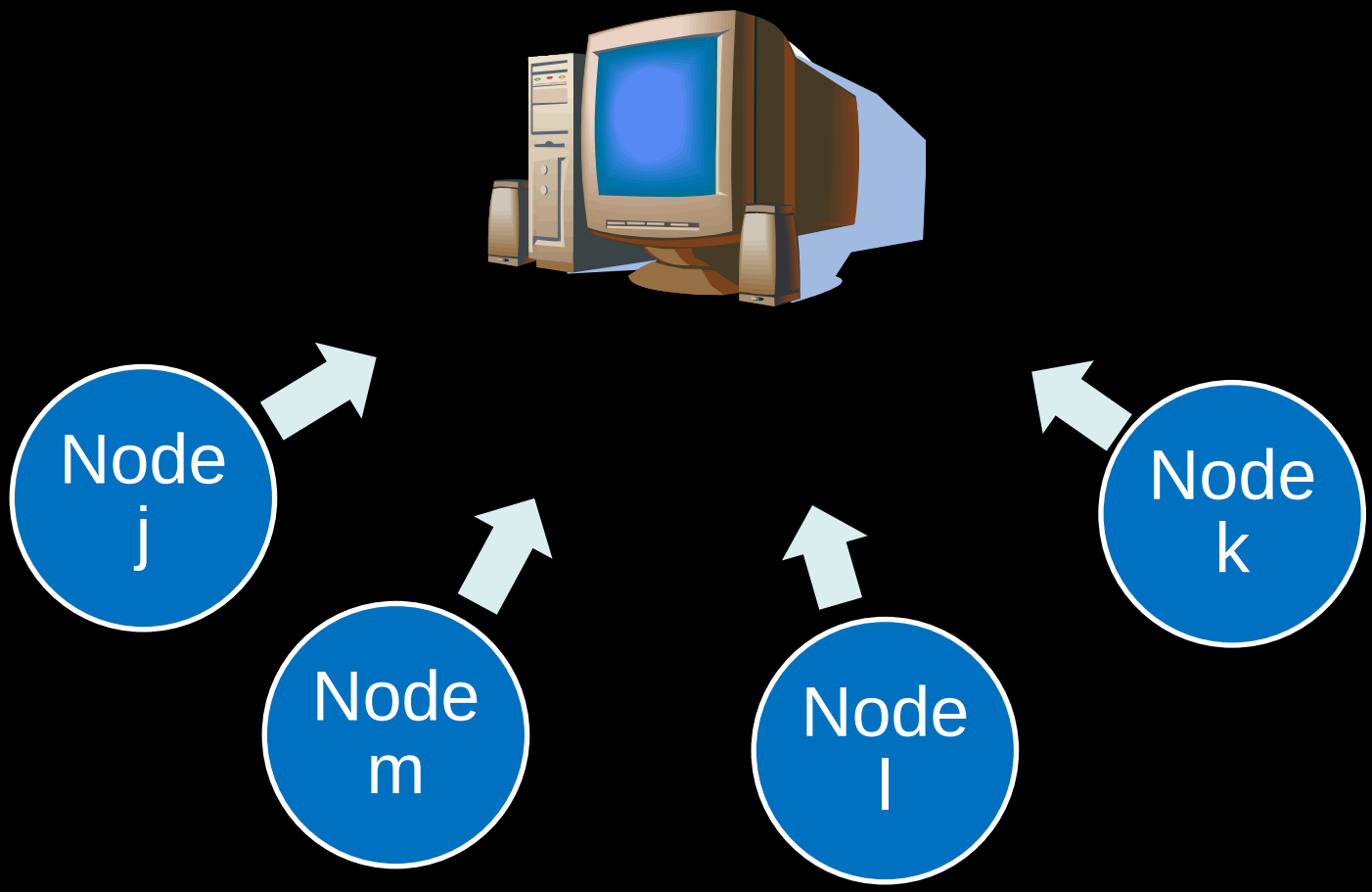
REPUTATION

Updates reputation for each of the nodes [I, j, k,l] i.e.
R_{ij}, R_{ik}, R_{il}, R_{im}

trust

External evidence

Community of Sensor Nodes



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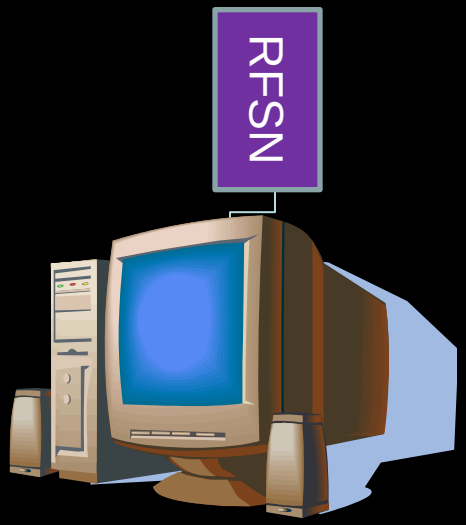

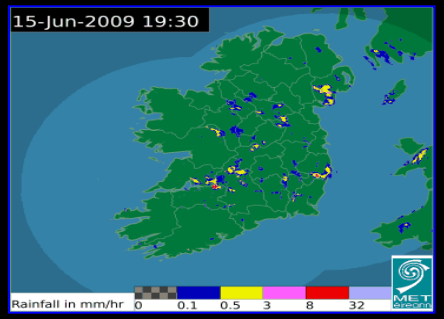

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External evidence

Acknowledgements

- Beaufort Research Awards in Marine Sensing
- Marine Institute
- CLARITY – Centre for Sensor Web Technologies, Science Foundation Ireland under grant 07/CE/I1147
- HRDDS (GHRSST Project) and David Poulter at the National Oceanography Centre, Southampton, UK