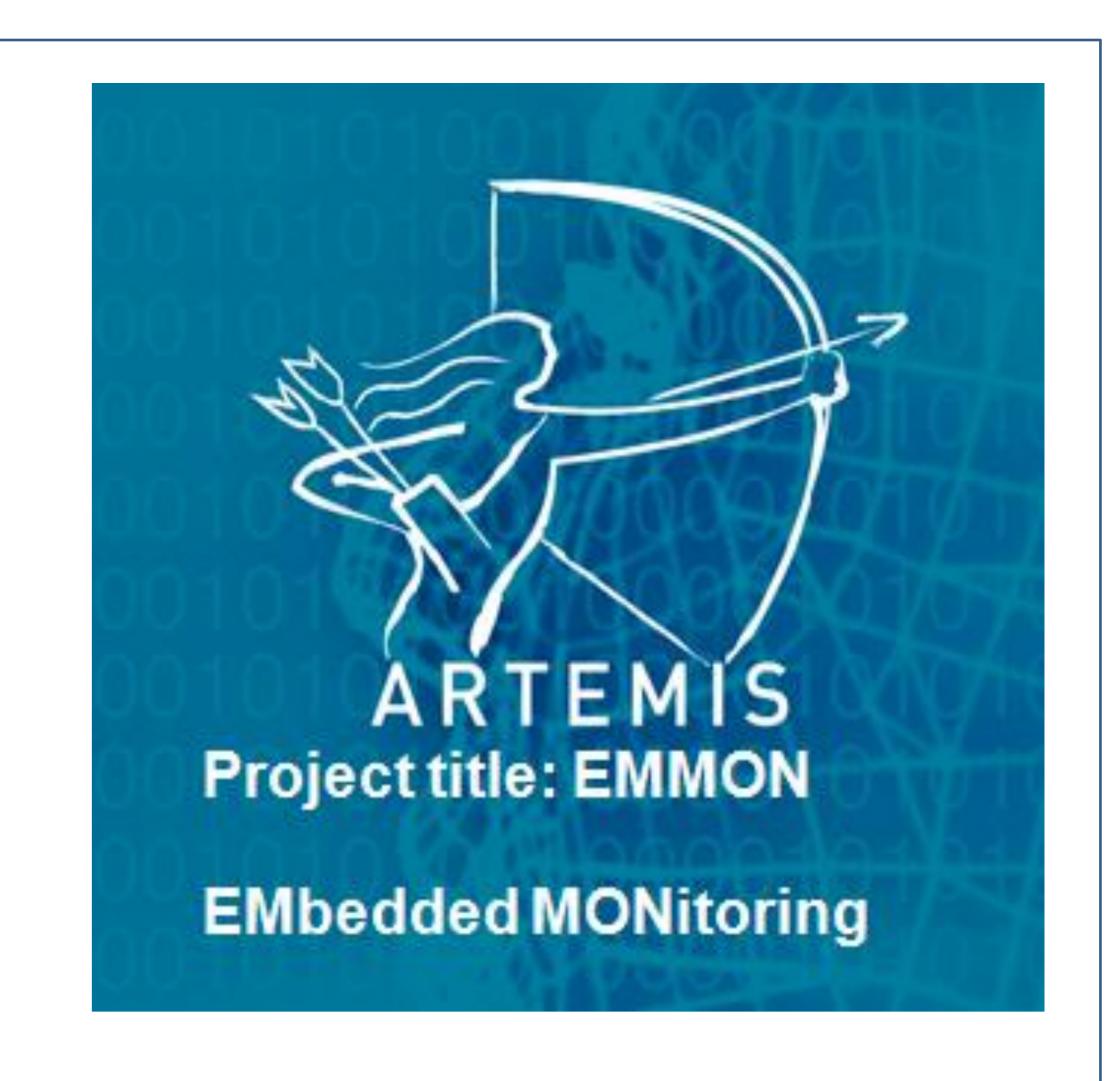# http://www.artemis-emmon.eu

A WSN System Architecture for Large Scale and Dense Real-Time Embedded Monitoring

ARTEMIS
Project title: EMMON
EMbedded MONitoring

EMMON Objectives

State-of-the-art:
- 99% Protocols/Algorithms vs. 1% Applications
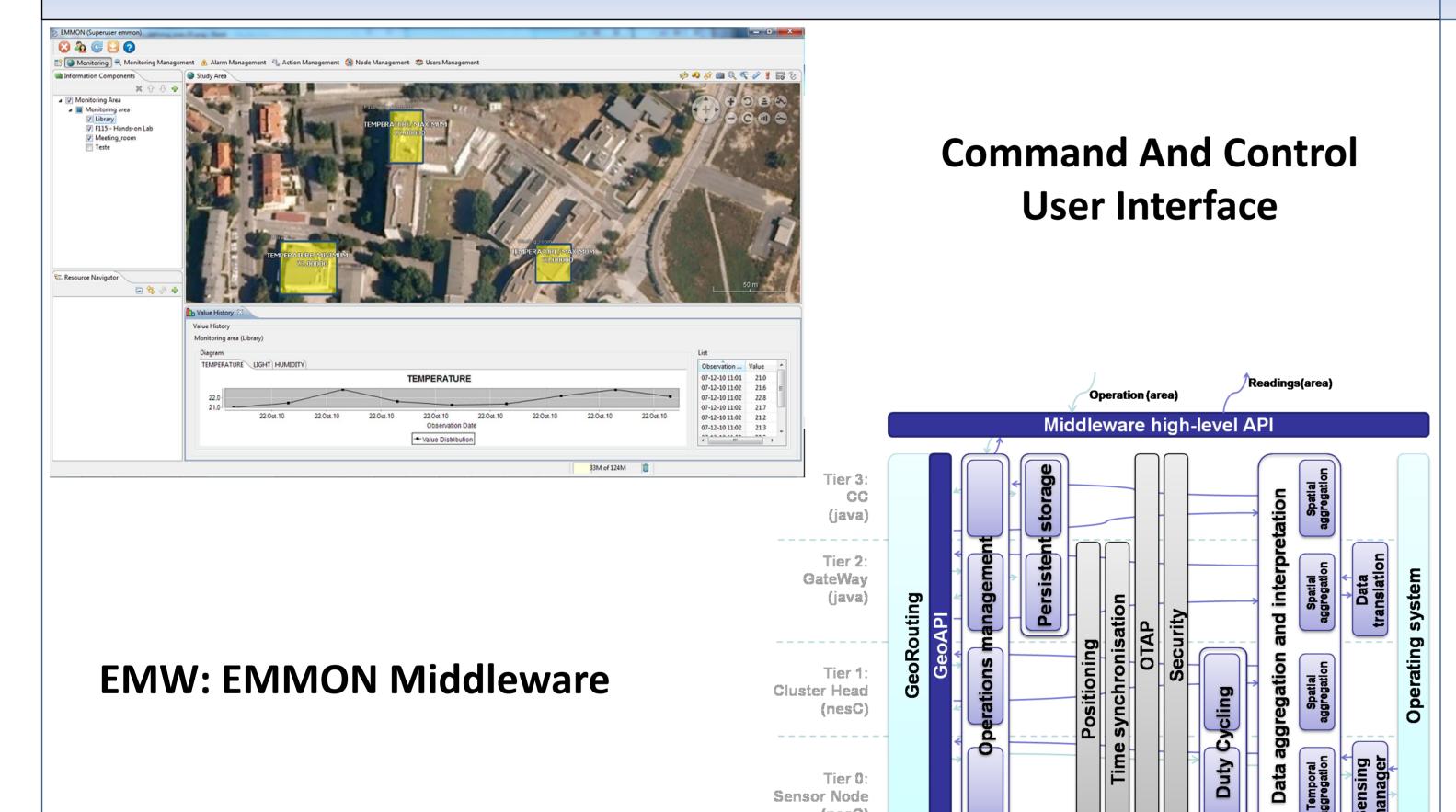- few WSN system architectures reported are either inappropriate or incomplete

EMMON fulfils this gap:
- Complete System Architecture:
  * Communication Protocol Stack;
  * Middleware;
  * Command And Control.
- System Planning and Analysis Toolset:
  * Deployment planning and network dimensioning;
  * Protocol Simulation;
  * Remote Programming and Testing tools.

System Architecture

Hierarchical Multi-Tiered Network Architecture

Tier M — Command & Control Clients
Internet — TCP/IP
Tier N — Command & Control Server
3G — Internet / Ad hoc Network — IP/3G,WiFi,WiMax
Tier 2 — Fixed Gateways
WiFi/IEEE802.15.4
Tier 2.b — Portable Devices
IEEE802.15.4
ZigBee Cluster Tree/IEEE802.15.4
Tier 1 — Cluster Heads
IEEE802.15.4
ZigBee Star/IEEE802.15.4
Tier 0 — Sensor Nodes

ZigBee-like Cluster Tree WSN model
(Time Division Cluster Scheduling)

C&C and EMW

Command And Control User Interface

EMW: EMMON Middleware

EM-Set: The EMMON Toolset

Inputs:
- Field's size
- Sensing coverage

Network Deployment Simulator (JiST/SWANS tool)

Outputs:
- Number of WSN Patches
- Number of SNs
- Nodes' positions

TDCS scheduler (MATLAB tool)
Outputs:
- Parent <-> Child
- Cluster scheduling

Worst-Case analyzer (MATLAB tool)
Outputs:
- Worst-Case E2E delay Real Time

Network Protocol Simulator (OPNET model)
Outputs:
- E2E delay Best-Effort
- E2E delay Real-Time
- Packet loss
- Energy consumptions

Programming Application
Hardware Testing
WSN
Network Protocol Analyzer

Analytical vs. Simulation vs. Experimental Results

Tot Nodes	r (clusters)	Σ {SNs per CH}	Rm	Lm	BO	BI [s]	Pkt Loss [%]	CAP - Best Effort End-To-End Delay [s] SIMULATION avg	std	max	EXPERIMENTAL avg	std	max	CFP - Real Time End-To-End Delay [s] SIMULATION avg	std	max	ANALYTICAL WorstCase
25	5	5	4	2	7	2.048	0.56	1.73	1.12	3.73	1.32	0.36	2.06	1.95	1.13	3.92	5.82
45	5	10	4	2	7	2.048	2.39	1.80	1.12	3.80	1.59	0.40	1.99	1.97	1.13	3.91	5.82
65	5	15	4	2	7	2.048	5.53	1.81	1.12	3.82	1.67	0.38	2.14	1.97	1.14	3.91	5.82
85	5	20	4	2	7	2.048	8.48	1.82	1.13	3.83	1.68	0.56	2.19	2.00	1.15	3.91	5.82
101	5	24	4	2	7	2.048	10.20	1.83	1.15	3.84	1.71	0.53	2.35	2.04	1.14	3.90	5.82
97	17	5	5	3	9	8.192	2.47	13.96	5.52	36.03	12.99	5.16	45.70	14.65	5.35	34.02	41.86
257	17	15	5	3	9	8.192	10.29	16.28	6.58	47.02				14.45	5.30	23.53	41.86
401	17	24	5	3	9	8.192	13.08	16.38	7.49	44.20				14.61	5.36	23.53	41.86
97	17	5	3	4	9	8.192	2.75	22.56	12.89	109.90	10.84	5.89	23.85	22.03	12.89	68.73	69.87
257	17	15	3	4	9	8.192	10.84	23.86	12.53	116.30				22.15	10.70	62.82	69.87
401	17	24	3	4	9	8.192	13.32	20.97	9.67	54.85				19.17	8.14	55.62	69.87
97	17	5	2	5	9	8.192	2.14	23.18	9.03	38.97	25.14	7.87	95.38	24.44	9.00	57.94	94.76
257	17	15	2	5	9	8.192	10.49	27.11	11.47	75.04				24.79	9.17	52.78	94.76
401	17	24	2	5	9	8.192	15.16	28.22	13.02	78.44				24.17	9.44	54.93	94.76
121	21	5	2	5	9	8.192	2.23	23.08	9.04	39.13				24.22	8.91	57.34	94.76
321	21	15	2	5	9	8.192	10.28	26.30	11.58	76.18				23.95	9.48	54.09	94.76
501	21	24	2	5	9	8.192	12.84	27.15	12.35	67.63				23.92	9.39	38.89	94.76

Simulation, worst-case and experimental results

CAP Packet Loss Ratio

End-To-End Delay vs. Max Depth

DEMMON1: 300+ Nodes, Largest Single-Site Testbed in Europe