A Systematic Mapping Study on Edge Computing and Analytics

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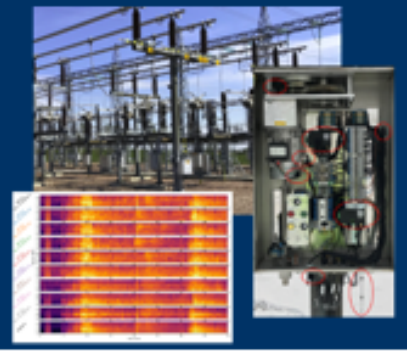
Position: PhD student in Embedded Systems at Åbo Akademi University, Turku, Finland
Focus: Edge related technologies applied in maritime sector
Skills: C++, Visual Studio, R, Office, TeX Studio, Arduino, Linux

EDGE project: Edge Analytics for Smart Diagnostics in Digital Machinery Concept


Engine test bench (VEBIC, UVA)
- Sensing/validation
- High performance embedded computing
- Data transfer (low connectivity)
- EDGE updates
- Boost pressures, temperatures
- Image recognition

Substation switching devices
- Reliability
- Electrical and acoustics
- 1st generation data
- 2nd generation edge combatible

Crane
- Predictive maintenance / remaining lifetime
- Predict increases mechical load
- Motor, bearings
- Current, torque, speed, vibration, etc.

Forest machinery – bus data
- Fault codes
- Prediction
- Sensor and process information
- Low connectivity
- EDGE demands
- Time and safety critical

Ship engine
- Unmanned machine room
- Acceleration sensors
- Prediction
- EDGE demands
- Low connectivity at some locations
- Validation

Why did we do this?

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- In an early meeting with researchers and companies we discovered that in this group we have a lack of knowledge in status of edge computing and analytics
- We decided on testing a systematic way of doing our project which may be adopted in the running projects

What is a Systematic Mapping Study(SMS)?

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- Systematic mapping studies are designed to give an overview of a research area through classification and counting contributions related to the classification categories, by following a specific format
- The SMS methodology requires having an exact search string used for responding the research questions related to the study
- Search string contains specific keywords that previously generated important results and it has been formed from multiple attempts of different words combined

Research questions

- RQ1: Which fields apply edge computing?
- RQ2: What methods or algorithms are used in edge computing?
- RQ3: What edge framework proposals exist?
- RQ4: How do proposed edge framework solutions perform?
- RQ5: What is the standardization level for edge computing?
- RQ6: How are the edge framework proposals evaluated?

Search strings and digital libraries

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1. edge AND (Comput* OR Algorithm OR Analy* OR Defect OR Malfunction OR Anomal*) AND (Performance* OR Complexit* OR Energy)
2. edge AND (Comput* OR Algorithm OR Analy*) AND (Defect OR Malfunction OR Anomal*) AND (Performance* OR Complexit* OR Energy)

Digital libraries where the search strings were applied:

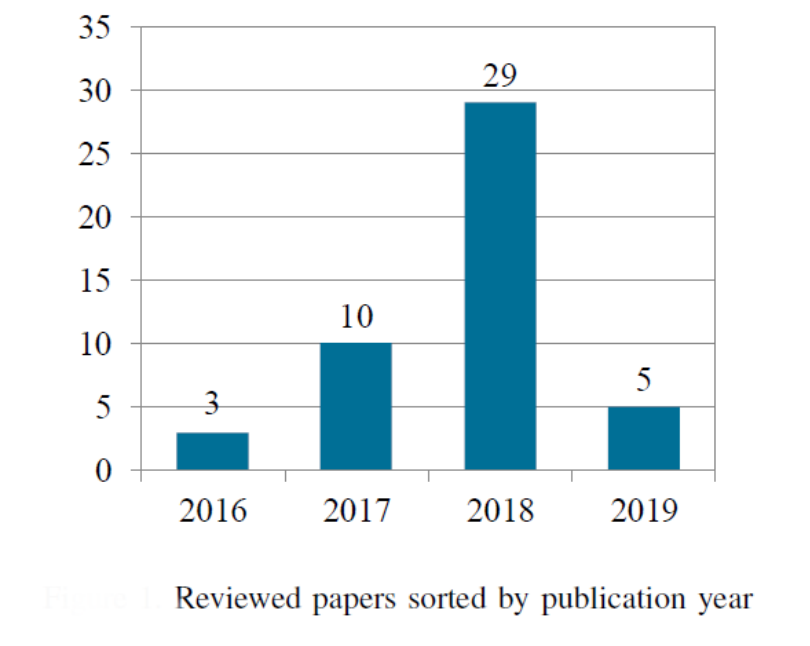
- IEEE Xplore
- ACM Digital library
- ScienceDirect

Key performance indicators of the study

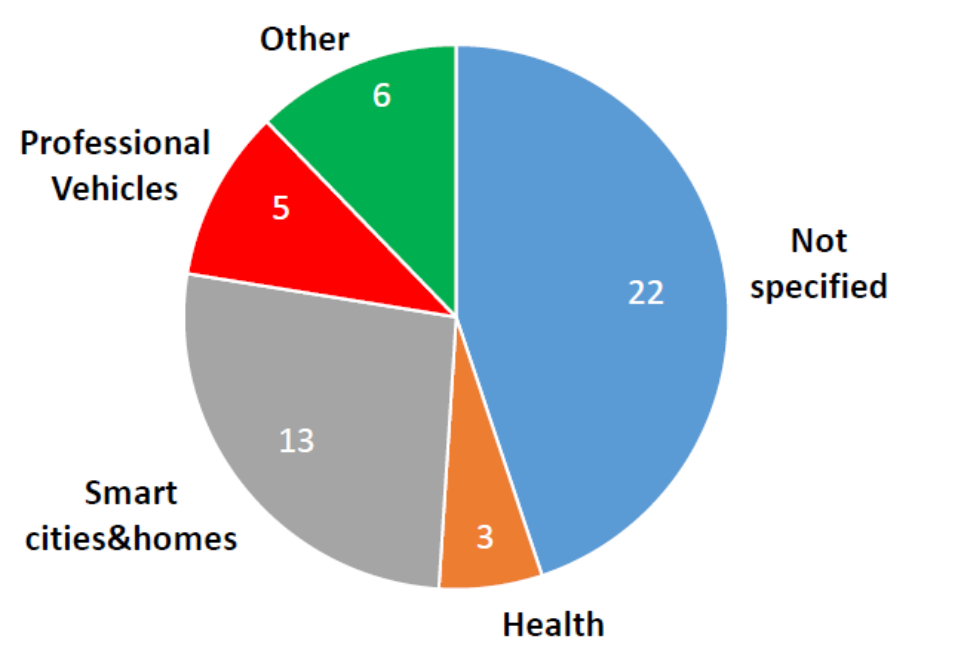
Phase	Number of papers
Initial search results without duplicates	912
After title and abstract screening	118
After full text screening	58
After quality assessment	47

The execution of the search strings against the databases was performed on April 10, 2019

Papers publication years and papers application domains



Reviewed papers sorted by publication year



Edge computing application domains from reviewed studies

Where is Edge analytics being used?

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Algorithm Output	Count	Papers	Description
Data Transmission/Reduction/ Mining	4	S1,S4,S24,S32	Data management and engineering
Power optimisation	9	S5,S6,S8,S18,S19,S21,S26, S27,S35	Power consumption reduction, anomaly detection
Task Scheduling & Operation Partitioning	16	S7,S11,S13,S16,S20,S23,S26,S27,S31,S34,S40, S41,S42, S44,S45,S47	Decision trees, appliance scheduling, routine handler, offloading algorithm
Anomaly Detection	3	S12, S13, S37	Vehicle anomaly detection, control loops, anomaly detection
Image Classification & Face Recognition & Video Processing & Pattern Recognition	5	S10, S17, S28, S29, S30	Image classification, face recognition, Markov model, image recognition, video processing
Audio Measurements & Time efficiency & Localization	3	S35, S39, S43	Mosquito wing-beats classification, BLE localization, delay reduction

What performance metrics are edge algorithms generating?

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Performance Metric	Count	Papers	Description
Real-time	15	S1,S12,S13,S24,S28,S29, S30,S34,S35,S36,S39,S40, S43,S45,S46	Computations are performed while the system is running. Results are available with minimal delay
Computational Efficiency	5	S2,S33,S37,S39,S41	Reduced computation time and memory due to the use of edge system
Energy Efficiency	29	S3,S4,S5,S6,S8,S9,S10,S11,S14,S15,S16,S18,S19,S20,S21,S22,S23,S26,S27,S29,S31,S32, S34,S35,S38,S43,S44,S45,S47	Reduced energy requirements for performing computations due to the use of edge system
Data Transmission	2	S25,S45	Reduced response times, improved transmission rates
Other	9	S7,S17,S27,S28,S30,S34,S36, S40,S42	Task scheduling, latency, network performance, flexibility, quality of service, system bandwith, runtime performance

Conclusions

- Term “edge” is rather new which focused our study on papers from 2016 onwards;
- Several papers addressed the edge devices themselves: task scheduling and power optimisation. Others papers focused on edge algorithms for image and face recognition, anomaly detection, data management and data engineering;
- Many papers applied their algorithms on simulation environments and few applied real implementations of edge technologies;
- Almost half of the papers did not specify their application domain, indicating that clear implementation strategies for some proposals did not exist;
- Among the applications domains specified, smart cities and homes were the dominating application domains, followed by professional vehicles, health domain and various other domains.