SCSS 2019
Software and Cyber Solutions Symposium: Benefits and Risks of Cloud Computing

Edge Computing: Use Cases and Challenges

Grace A. Lewis

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213

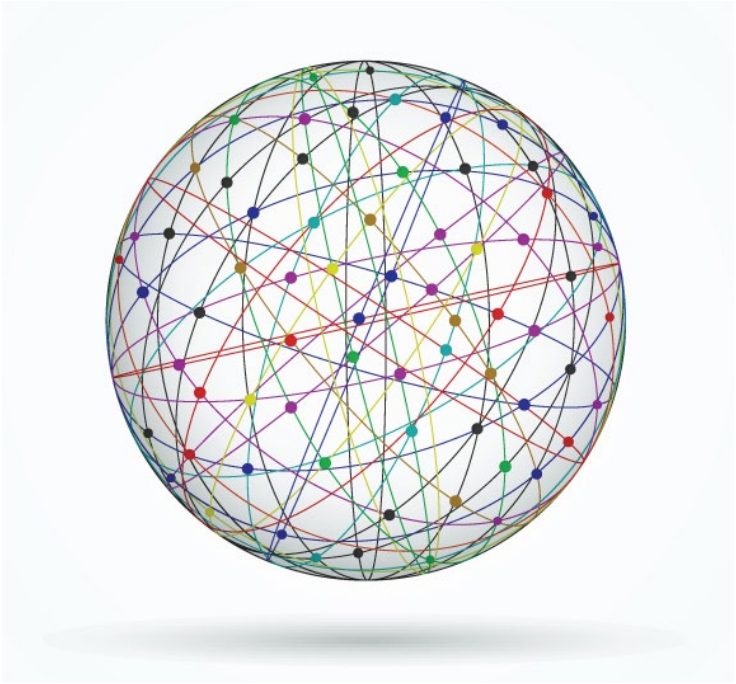
This material is based upon work funded and supported by the Department of Defense under Contract No. FA8702-15-D-0002 with Carnegie Mellon University for the operation of the Software Engineering Institute, a federally funded research and development center.

DM19-0872

Edge Computing

Idea is to push applications, data and computing power to the edge of the Internet, in close proximity to mobile devices, sensors, and end users

An early example is Akamai, with servers around the world to distribute web site content from locations close to the user (content delivery networks, or CDNs)



Edge Computing: Drivers

Latency

- data processing close to where it originates avoids round-trip time to the cloud

Bandwidth

- optimization of communication to and from the cloud

Privacy/security

- sensitive data stays local

Connectivity

- continued processing (in some cases) despite lack of connectivity to the cloud

Local dependencies

- data processing close to points of interaction with end users and other system components

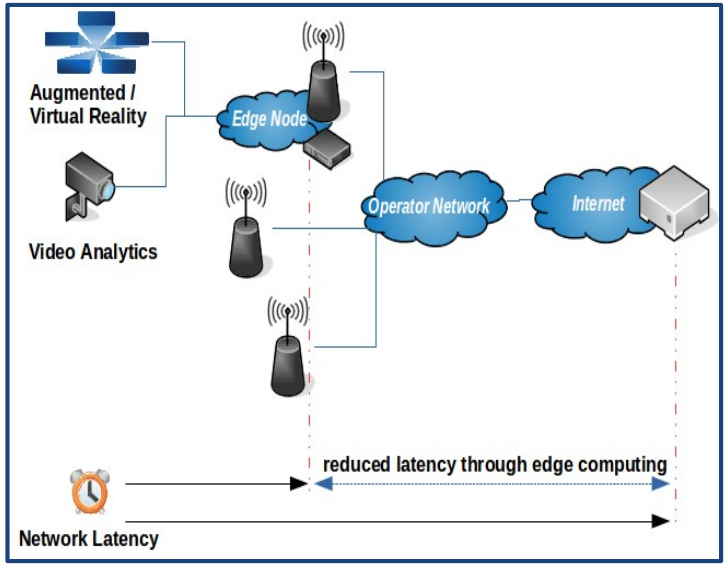
Edge Computing: The Telco View

Opportunity for providing edge computing devices in existing infrastructure

- e.g., micro data centers at the base of cellular towers

Multiple organizations seeking standardization: Multi-Access Edge Computing (MEC), Open Edge Computing (OEC), OpenFog consortium, etc.

Business model is still not clear: Who pays for the service? Consumer? Content Provider?



Edge Computing according to the Open Edge Computing Initiative [1]

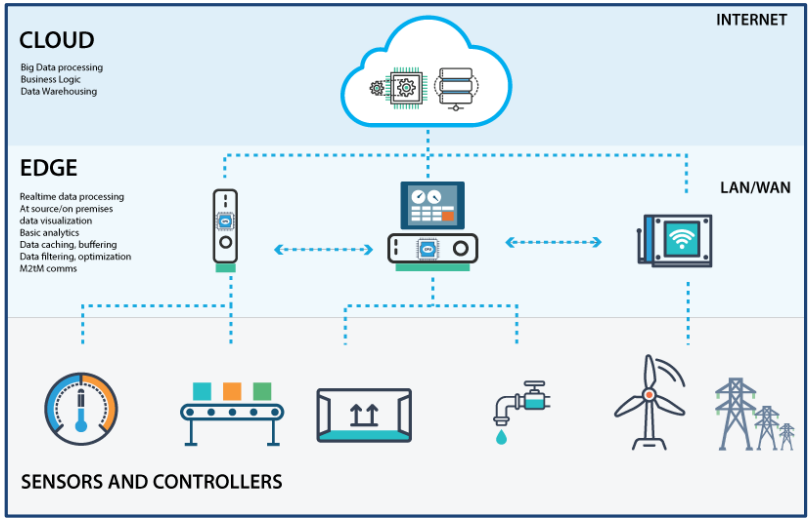
Edge Computing: The Cloud Provider View

Goal is mainly to provide

- Content Delivery Network (CDN) services
- IoT data processing and aggregation for data in transit to the cloud

Examples

- Azure IoT Edge — deploy business logic to edge devices and monitor from the cloud
- Amazon
  - AWS CloudFront — CDN Service, includes Lambda@Edge
  - AWS Greengrass — connected IoT devices can run AWS Lambda functions and other code on locally-collected data



Industrial IoT: IoT to Edge to Cloud [2]

Edge Computing: The “Appliance” View

Goal is to provide a “data center in a box” to push cloud computing capabilities to the edge

- Often combined with networking capabilities such as edge gateways and smart routers

Many players in this space, such as Amazon, Cisco, Dell EMC, HPE, etc.

Disconnected Operations

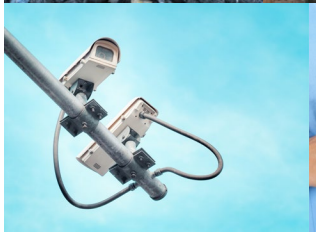
AWS Snowball Edge — large-scale data transfer service with an embedded computing platform (based on AWS Greengrass plus Lambda functions)

Snowball Edge Device [3]

Opportunities for DoD and Government

Edge Computing via “appliances” can provide computation and data to support a wide variety of missions

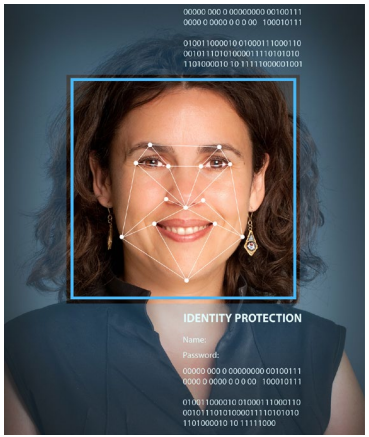
- Military
- Humanitarian
- Public safety
- Public service

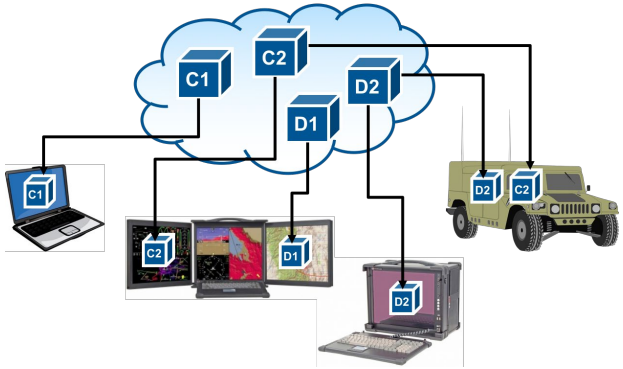


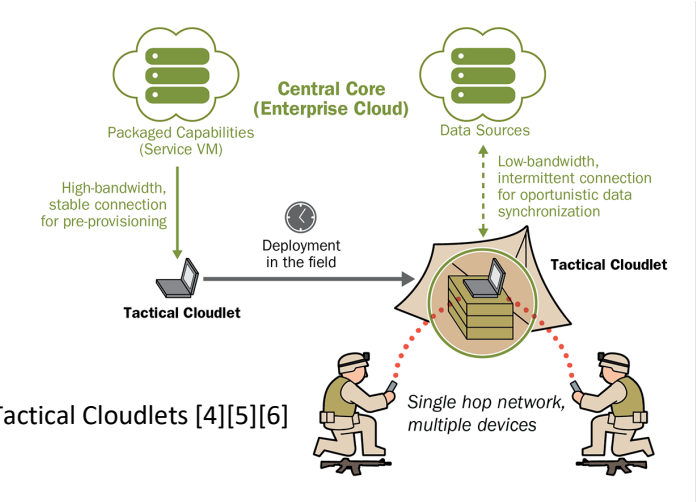
Computation and Data in Disconnected Environments

Providing computation-intensive capabilities and data at the edge when there is no access to the cloud

- Speech recognition
- Face recognition
- Speech translation
- Image recognition
- Image processing
- Air/water quality analysis







Tactical Cloudlets [4][5][6]

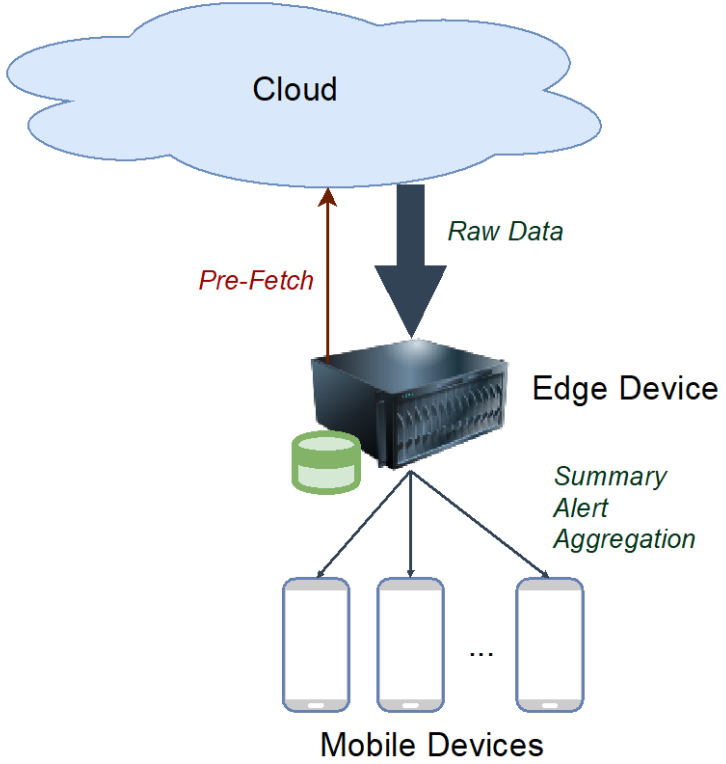
Data Pre-Processing, Filtering, and Pre-Fetching (Cloud to Edge)

Using edge devices to

- pre-process,
- pre-fetch, or
- filter unnecessary data from streams intended for mobile devices

Goal: Mobile devices receive only the data that they need, when they need it

- reduced bandwidth
- reduced latency
- reduced cognitive load

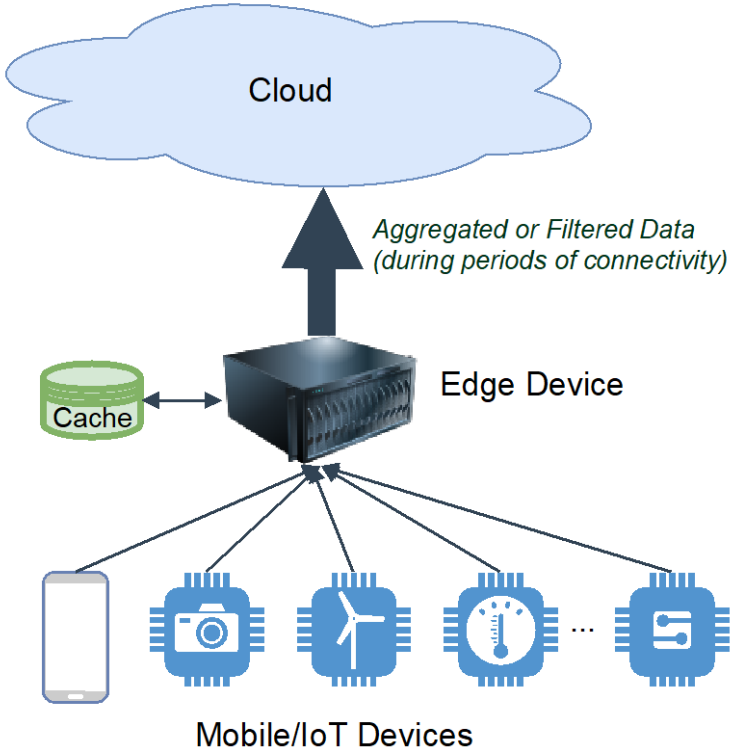


Data Pre-Processing and Caching (Edge to Cloud)

Using edge devices to

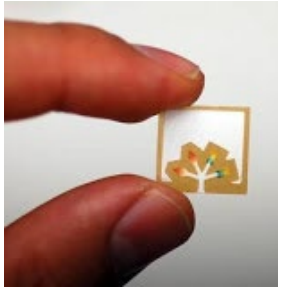
- pre-process, or
- cache

data heading for enterprise repositories



Field Operations

People that spend time away from their main offices or labs, such as researchers, medics, and sales personnel, can leverage portable surrogates to support their computation and data needs

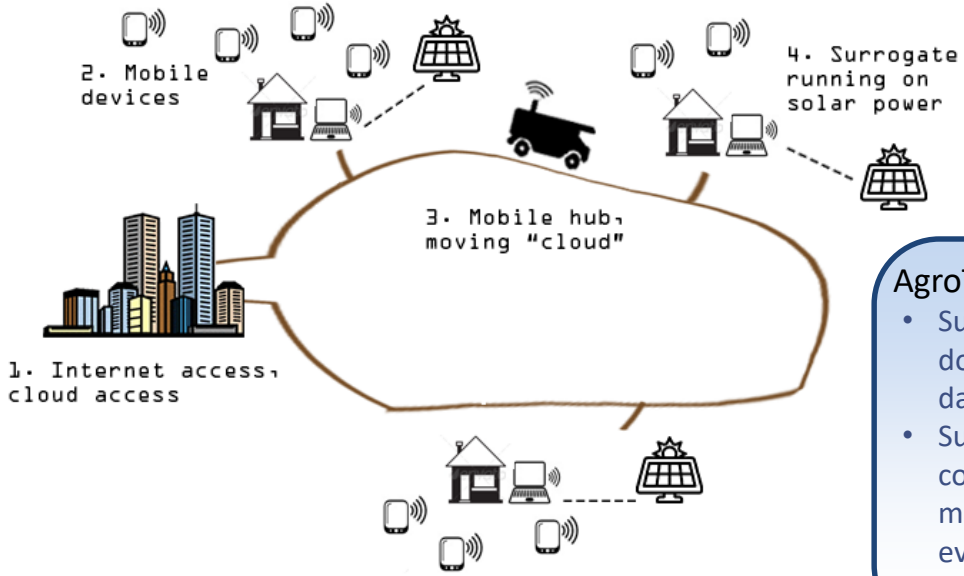


Leverages microfluidic paper-based analytical devices (µPADs)

PowerSense: Image Processing for Dengue Detection [7]

Resource-Challenged Environments

Less-privileged regions characterized by limited Internet access, limited electricity and network access, and potentially low levels of literacy can leverage surrogates to obtain information to support their communities



AgroTempus Features [8]

- Surrogates in villages download and cache data from mobile hub
- Surrogates upload field-collected data to the mobile hub which eventually syncs with the cloud

Challenges

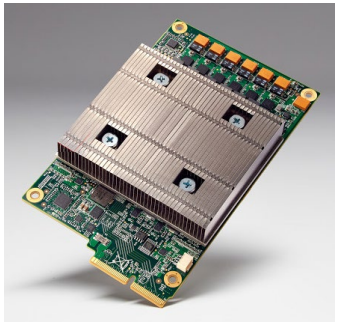
Hardware (especially in the context of Edge AI)

Privacy

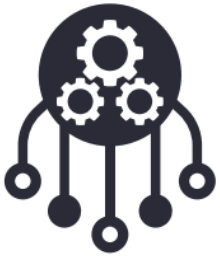
Security

Data and computation allocation to edge devices (especially at runtime)

Resource discovery



Google Edge TPU BETA [9]



The Joneses (2009)

Summary

Edge Computing is about pushing applications, data and computing power to the edge of the Internet, in close proximity to mobile devices, sensors, and end users

Edge Computing via “appliances” can provide computation and data to support a wide variety of missions

I challenge you to think about use cases for Edge computing beyond IoT

- Military
- Humanitarian
- Public safety
- Public service

References

[1] Open Edge Computing Initiative. http://openedgecomputing.org (2019)

[2] Open Automation Software. IIoT Edge Computing vs. Cloud Computing. https://openautomationsoftware.com/blog/iiot-edge-computing-vs-cloud-computing/ (2019)

[3] Amazon. AWS Snow Family. https://aws.amazon.com/snow/?c=17&pt=6 (2019)

[4] Echeverría, Sebastián, Grace A. Lewis, James Root, and Ben Bradshaw. "Cyber-foraging for improving survivability of mobile systems." In MILCOM 2015-2015 IEEE Military Communications Conference, pp. 1421-1426. IEEE, 2015.

[5] Echeverría, Sebastián, Dan Klinedinst, Keegan Williams, and Grace A. Lewis. "Establishing trusted identities in disconnected edge environments." In 2016 IEEE/ACM Symposium on Edge Computing (SEC), pp. 51-63. IEEE, 2016.

[6] Lewis, Grace A., Sebastián Echeverría, Dan Klinedinst, and Keegan Williams. "Secure VM migration in tactical cloudlets." In MILCOM 2017-2017 IEEE Military Communications Conference (MILCOM), pp. 388-393. IEEE, 2017.

[7] Matthews, Jerrid, et al. "PowerSense: power aware dengue diagnosis on mobile phones." Proceedings of the First ACM Workshop on Mobile Systems, Applications, and Services for Healthcare. ACM, 2011.

[8] Brion, Reuel. Demonstrator for a Cyber-Foraging System to Support Agricultural Knowledge Exchange in Resource-challenged Environments. Masters Thesis. VU University Amsterdam. 2015.

[9] Google. Edge TPU BETA. https://cloud.google.com/edge-tpu/ (2019)

Contact Information

Grace A. Lewis
Tactical and AI-Enabled Systems (TAS) Initiative
Software Solutions Division (SSD)

Software Engineering Institute
4500 Fifth Avenue
Pittsburgh, PA 15213-2612
USA

Phone: +1 412-268-5851
Email: glewis@sei.cmu.edu
WWW: http://www.sei.cmu.edu/staff/glewis