Secure Data-Intensive Services with IoT, Fog Computing and LASAGNE

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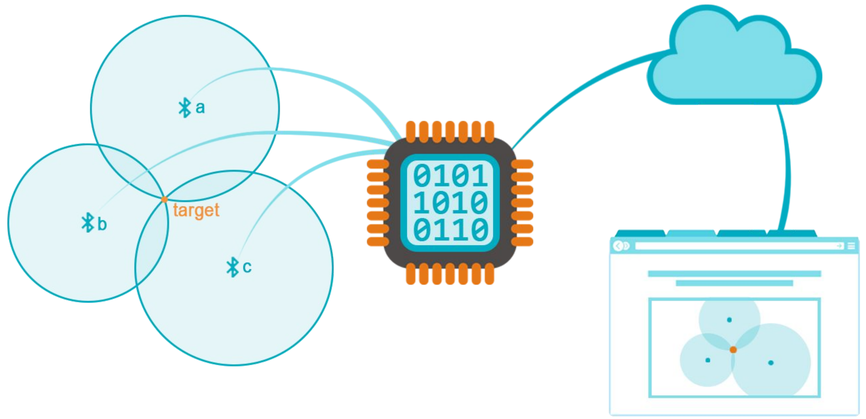
Introduction

- The Internet of Things (IoT) is an assortment of networked devices that contain sensors and actuators to facilitate the collection and exchange of data.
- Vast amount of data generated by IoT devices is time sensitive and requires significant network bandwidth to transport to the Cloud.
- Fog Computing seeks to alleviate this reliance on the network, where data is processed on the edge of a local network with low latency, with computations published to the Cloud [1].
- Layered Approach to Service Architectures for a Generic Networked Environment (LASAGNE) facilitates easy deployment of service components [3][4]. By employing a secure, data-centric publish-subscribe communication approach, the main goal of this project is to experiment using services implemented in LASAGNE to determine how employing a Fog Computing approach can improve performance of networked applications.

Objectives

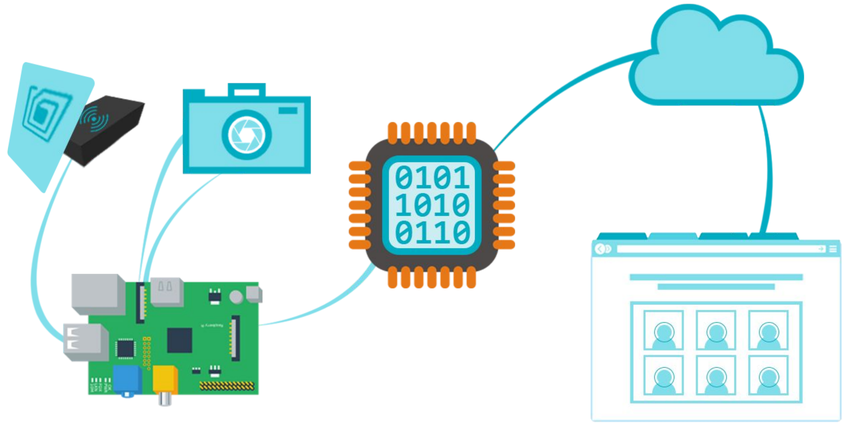
- Based on examples discussed in the Amazon Web Services (AWS) Innovate conference [2], design and develop two usage scenarios using LASAGNE services: a Bluetooth device trilateration application and an RFID-triggered face detecting camera application, which use multiple Raspberry Pi's as the IoT sensors.
- Design the usage scenarios with an emphasis on the security of the transmitted data, providing message confidentiality, authentication, integrity and protection against replay attacks.
- Leverage LASAGNE's simple redeployment facilities by changing the location of service component deployment to perform experiments.
- Experiment with the usage scenarios contrasting a Fog vs. Cloud computing approach, to determine if and how each application may benefit from using a Fog approach when internet bandwidth is reduced and latency is increased.

Experimental Studies



Study 1: Beaconisis

- Multiple sensors (or beacons) each detect a target device via Bluetooth signal strength readings and deliver these to a server for filtering of noise and conversion to distances, for accurately computing the target device's location.
- Using trilateration, the processing service uses the locations of each sensor and its distance reading from the target, in order to compute the relative position of the target.
- Performed in real-time, the computations are delivered to a web server for visualising where each sensor and the target device are located.
- Deploying the service which computes the trilateration result on the Fog relieves the Cloud of computation, reducing bandwidth consumption outside of the network.



Study 2: Face Detection with RFID

- An RFID reader attached to a Raspberry Pi triggers the Pi's camera to take a photo when an RFID tag is in range.
- The Raspberry Pi securely publishes the picture to a subscribing Processing Service. The Processing Service uses the OpenCV library to detect faces and draws a circle around them.
- The Processing Service securely publishes the result to a subscribing Cloud Service, which can then displays the resulting image in a web application.
- Deploying the Processing Service which detects the faces within an image on the Fog reduces the load on the Cloud and the outer network.

What is LASAGNE?

- The LASAGNE framework is a "Layered Approach to Service Architectures for a Generic Networked Environment" and has been developed by the Defence, Science and Technology (DST) group. The framework is suited for efficient, scalable, Internet of Things (IoT) style applications written in C++ as reusable services.
- Features platform, operating system and vendor middleware independence (leveraging the ability to create portable applications), modularity, point-to-point and data-centric publish-subscribe communication models, and high performance intra/inter-process communication.
- Built on the open-source ACE framework which provides a large set of classes implemented according to the Pattern Oriented Software Architecture (POSA) approach. Point-to-point and object centric communication (including a discovery service) is provided by The ACE Object Request Broker (TAO).
- Supports four Data Distribution Service (DDS) implementations with middleware independent access through a meta-programming layer.

Security

- OpenDDS does not currently support security, as such we have implemented our own secure communication. Our implementation of security has focused on securing the application layer 'payload' itself.
- The payload is encrypted with AES-128 encryption using CBC block cipher mode, provided by the Crypto++ library, to ensure data is kept confidential.
- Hash-based Message Authentication Code (HMAC) is performed on the payload using SHA-256 to ensure the message has originated from an authenticated source and its integrity is maintained.
- A unique identifier in each topic is checked to protect against replay attacks.

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References

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