From IoT to Cloud:Research Platform for IoT/Cloud Experiments

Jinfeng Lin, Jacob Colleran(advisor), Jason Anderson (advisor), Zhuo Zhen (advisor), Kate Keahey (advisor)

NIMBUS

IoT studies leverage a wide range of lightweight hardware for collecting and processing data in the field. Limited by the resources on the devices, IoT systems have to interoperate with cloud platforms for addressing computation intensive tasks such as image processing, application backend supporting and centralized data storage. Therefore, a testbed for IoT/Cloud experiments should provide infrastructure for IoT to cloud communication, computation deployment, and hardware resource management. With these functionalities, users can focus on research problems without distraction from manually constructing experiment environments. Though cloud providers such as Google, Amazon, and Microsoft all provide IoT to Cloud solutions in general, this commercial model is not entirely compatible with research purposes. We propose a framework named Chameleon IoT testbed (CHIoT) that extends the Chameleon bare-metal cloud resources to support general IoT to Cloud experiments

What are the Research Problems in IoT/Cloud ?

IoT Category	Description
Application	Develop IoT based applications to address a specific type of challenge
Sensor sample strategy	Control sensor behaviors to improve efficiency and save energy
Network protocol	Improve network efficiency and reduce energy consumption
Security	Address security challenges for devices and networking
Edge computing	IoT devices as computation resources for leveraging data locality
Cloud service	Develop services on cloud to support IoT activities
Architecture	Designs new interaction patterns among devices
Other	Not belong to the above categories

We randomly sampled 65 experiments from 5 IoT conference/journal from 2017 to 2019 as our study cases and categorize them into 8 topics.

Limitation of Commercial IoT Platform

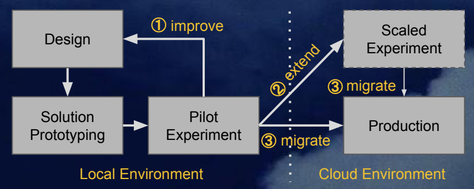
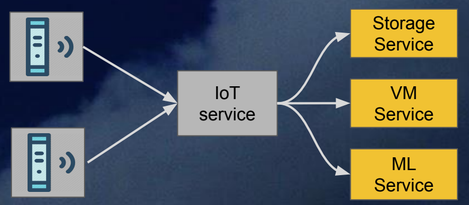


Fig. General IoT research life cycle with 3 stages



Service based commercial IoT Solution

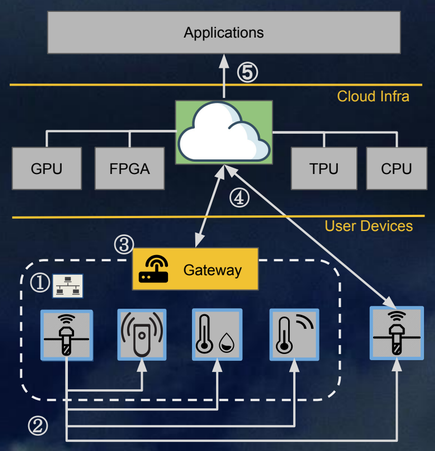
Flexibility. Commercial IoT provide limited support for software prototyping in stage ①

Portability. Commercial IoT solutions are not compatible with each other or private clusters

Transparency. Service oriented design constraints assessment of execution details

Isolation. VM neighbors can interfere performance related experiments and threat result reproductivity

Testbed to Support IoT Research



A testbed should have following functionalities to support IoT experiments in general

① Manage devices
- Create device groups with gateway devices
- Add/Remove devices in an experiment

② Machine to Machine Messaging
- Exchange multimedia message between devices

③ Computation On Edge Device
- Deploy user defined function on edge hardware

④ Device To Cloud Messaging
- Transport message from sensors directly
- Exchange message between edge and server

⑤ Leveraging Cloud Resources
- Provide hardware resource to support user defined functionality

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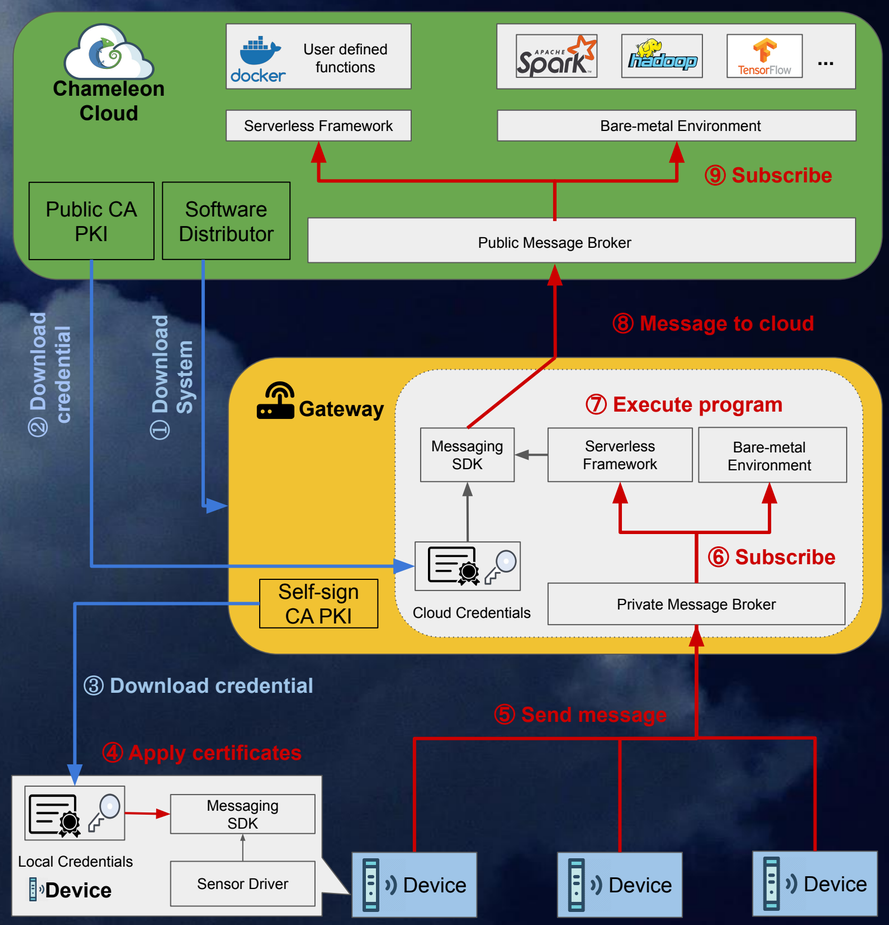


System Components:

Cloud System: An IoT service hosted on Chameleon for cloud-edge communication
Gateway System: An IoT service host on a user gateway to manage a group of IoT devices
SDK: Communication interface between the edge system and cloud infrastructure

Setup and register devices

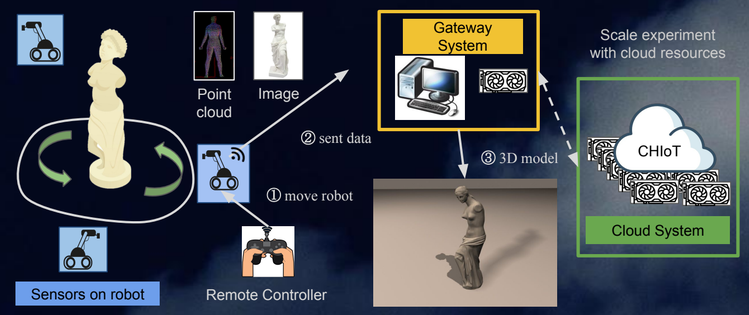
1.Download Gateway System and install it on a user devices
2.Download cloud credentials for gateway through HTTPS for registration
3.Download local credentials for devices. This device will be registered in gateway to formulate a local device network

Leverage CHIoT System

4. Devices apply credentials to SDK
5. Devices send message through MQTT
6. Message subscribed by topics at runtime
7. Programs runs on serverless or bare-metal environment to process data
8. Processed data will transport back to cloud through SDK
9. Cloud application will further digest data

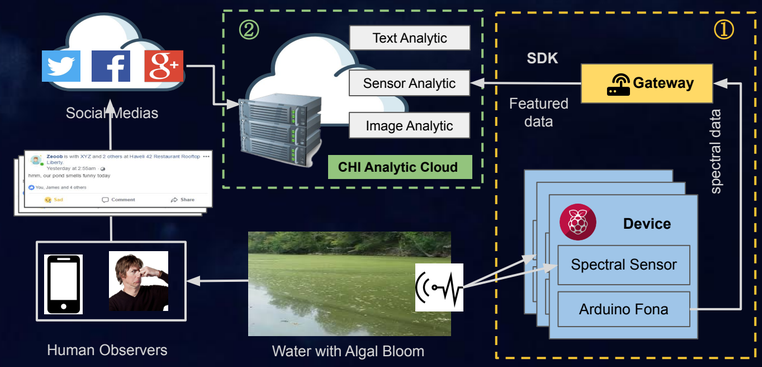
Usage Cases

1.Scale Experiment with cloud resource



User installs CHIoT Gateway System on desktop and connects the robot. Deploy 3D model generation algorithm to single GPU on gateway or scale to GPU cluster on Cloud

2.Flexible infra for multideida data processing



Researchers combine social media with sensor data to monitor and predict algal bloom in a water body
Researchers can leverage CHIoT Gateway System to construct a device group as ① which manage multiple Pi devices
Researchers can attach local system ① to any cloud by replacing SDK

Conclusion

We identified the common IoT/Cloud research requirements by conducting a literature review. Based on our observation, we claim that a testbed supporting communication, computation and management can facilitate IoT/Cloud research in general. Therefore we designed CHIoT as a 3 component system to satisfy the requirements articulated in our study. We believe this system can overcome the limitation of existing commercial IoT solution and is more applicable for research purpose. However, CHIoT adopts standard communication and security protocols as the default implementation, studies which aim to improve or replace those mechanisms are not support by CHIoT for current implementation.

Acknowledgements