IRA A. FULTON SCHOOLS OF engineering

school of computing, informatics, & decision systems engineering

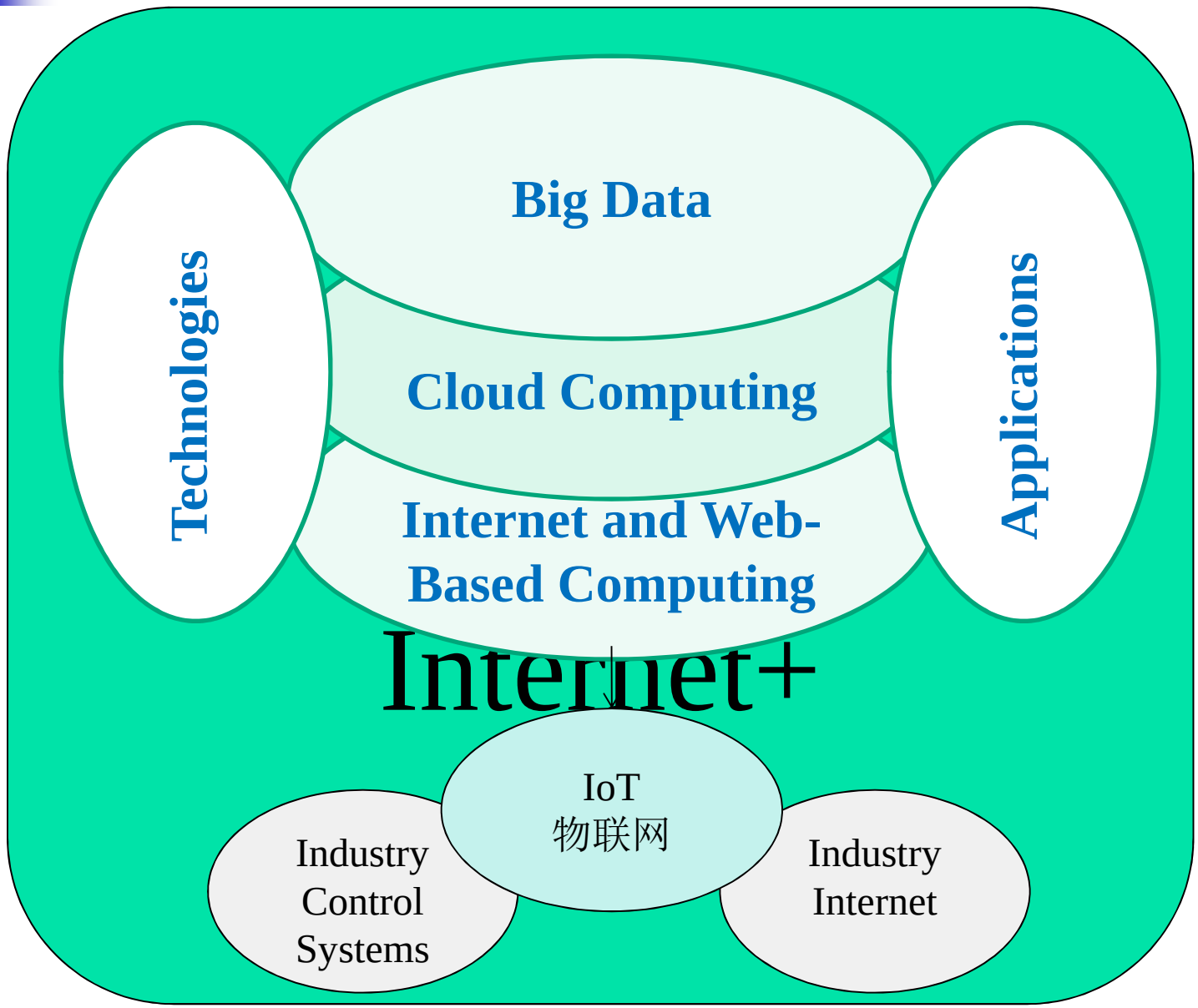
Introduction to Engineering Using Robotics Experiments

Behind the Internet+:

Internet of Things, Cloud Computing, and Big Data

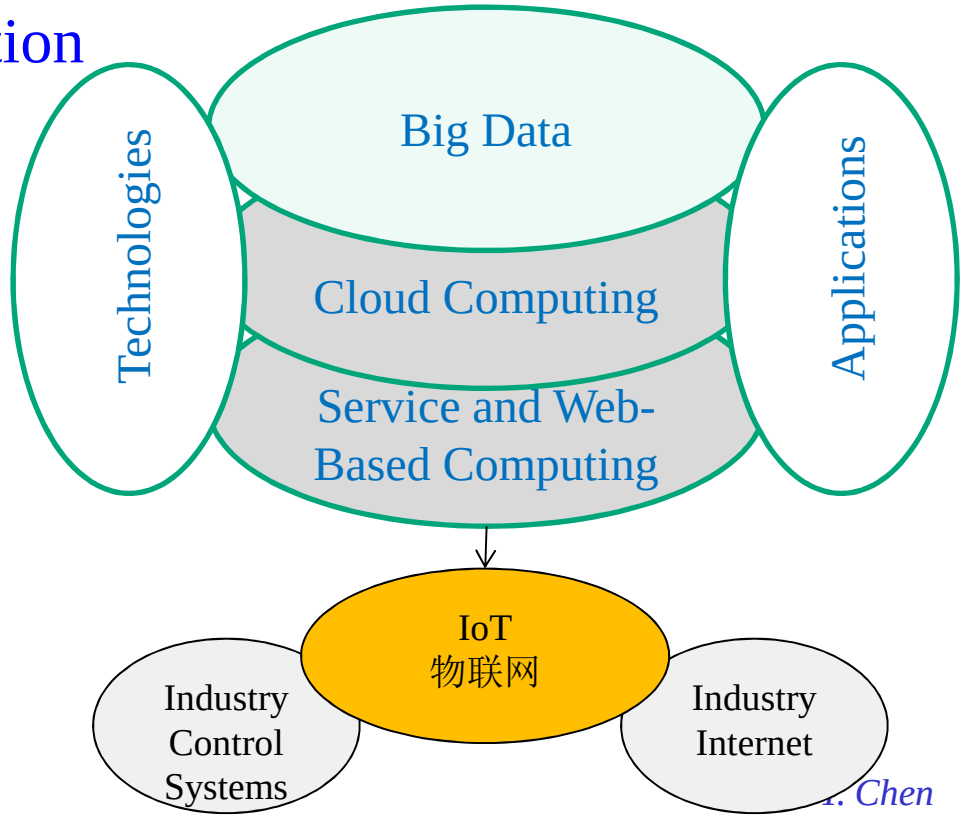
Yinong Chen
Arizona State University, U.S.A.
http://www.public.asu.edu/~ychen10/

The Big Things behind Internet+



Lecture Outline

- **Internet of Things and Robot as a Service**
  - Device as a Service
  - Robot as a Service (RaaS)
  - My RaaS software and hardware for Computer Science Education



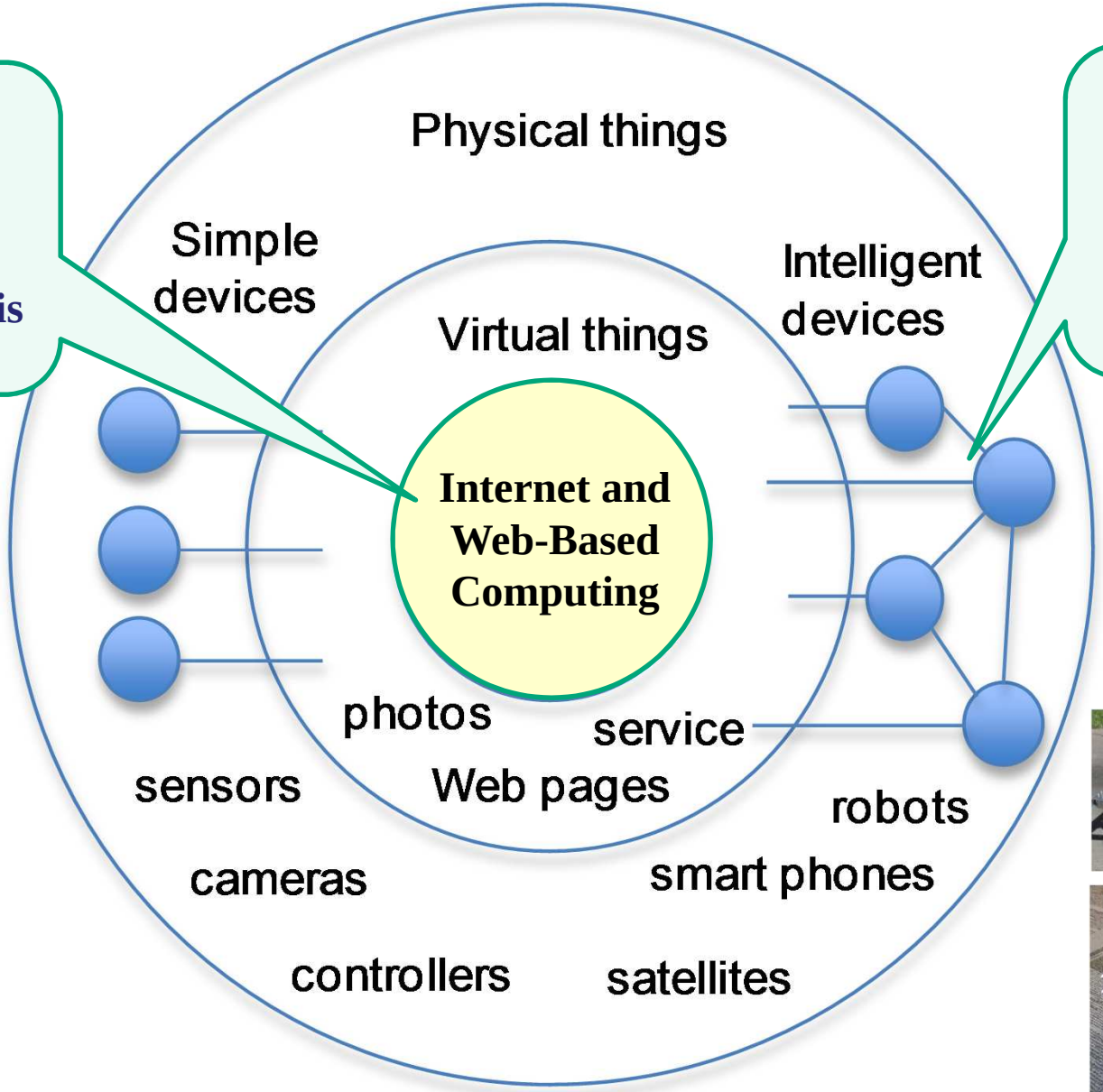
IoT and IoIT

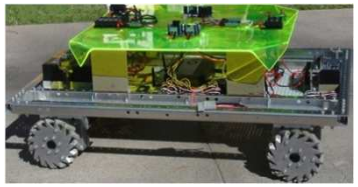
Scale out

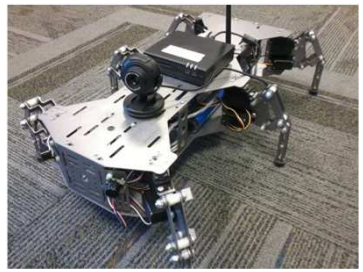
Web-based computing is the engine of IoT, and Big Data analysis is the fuel

Distributed intelligence adds benefits to centralized computing

Scale up







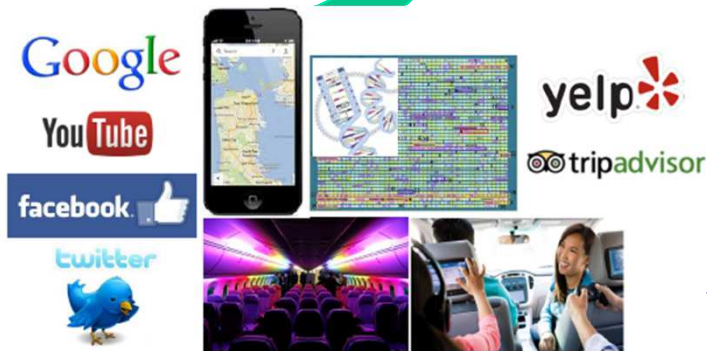
15B IoT Devices are the main Source of Big Data

Device-Generated Data

Big Data

Human-Generated Data

Cloud Computing



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Definition of RaaS

By Yinong Chen

Robot as a Service

From Wikipedia, the free encyclopedia

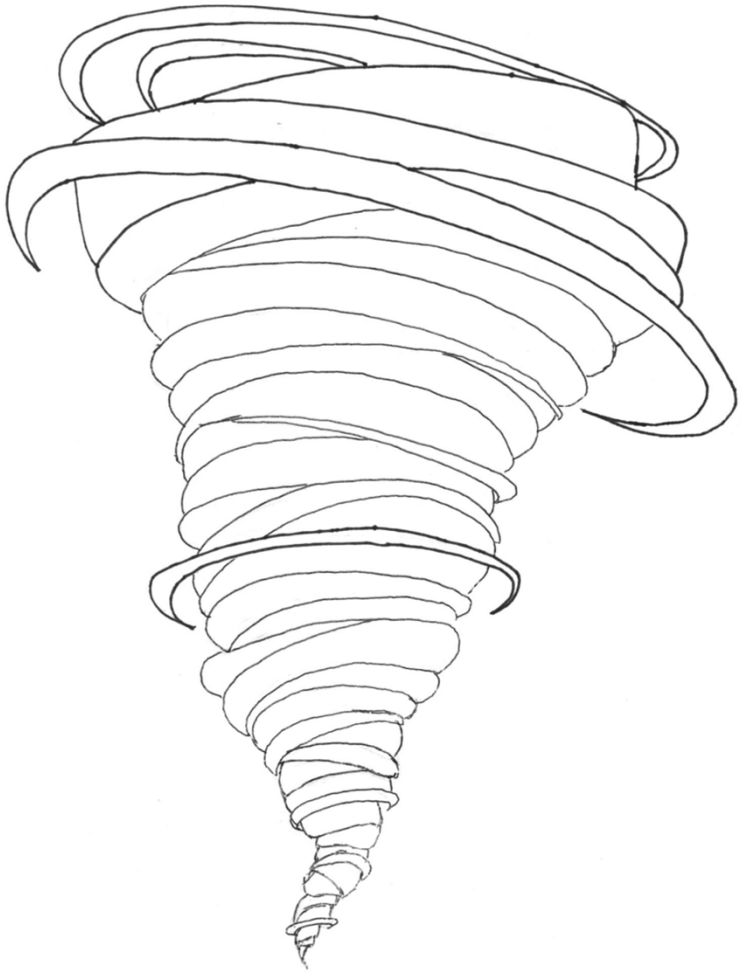
Robot as a Service (or RaaS) is a cloud computing unit that facilities the seamless integration of robot and embedded devices into Web and cloud computing environment. In terms of Service-Oriented Architecture (SOA), a RaaS unit includes services for performing functionality, a service directory for discovery and publishing, and service clients for user's direct access.[1][2] The current RaaS implementation facilitates SOAP and RESTful communications between RaaS units and the other cloud computing units. Hardware support and standards are available to support RaaS implementation. Devices Profile for Web Services (DPWS) defines implementation constraints to enable secure Web Service messaging, discovery, description, and eventing on resource-constrained devices between Web services and devices. RaaS can be considered a unit of Internet of Things (IoT), Internet of Intelligent Things (IoIT) that deal with intelligent devices that have adequate computing capacity,[3] Cyber-physical system (CPS) that is a combination of a large computational and communication core and physical elements that can interact with the physical world,[4] and Autonomous decentralized System (ADS) whose components are designed to operate in a loosely coupled manner and data are shared through a content-oriented protocol [5] .[6]

What is RaaS in Simple Words

RaaS (Robot as a Service) is

- an Embedded Intelligent System
- an Internet of Intelligent Thing
- a Cyber-Physical System
- an Autonomous Decentralized System
- a Service in Web and in Cloud Computing
- a Mobile Computing System
- a Real-Time System

Spiral Model of Computing System Development



Distributed Big Data Processing

support

Big Data Processing

support

Internet of Intelligent Things
and
Robot as Service

Centralized Computing (Cloud Computing)

Distributed Computing (Clusters)

Centralized Computing (Mainframe)

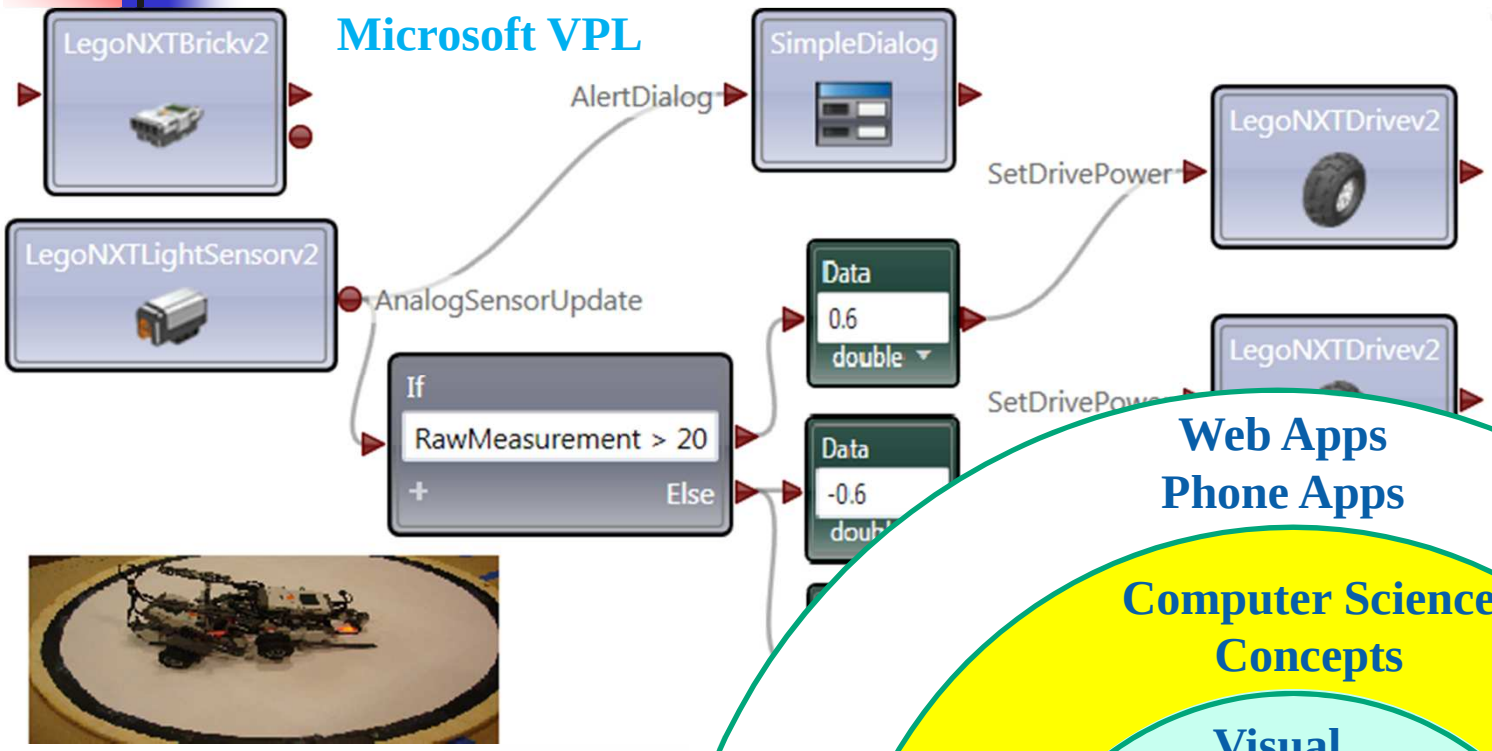
My RaaS Platforms and Implementations

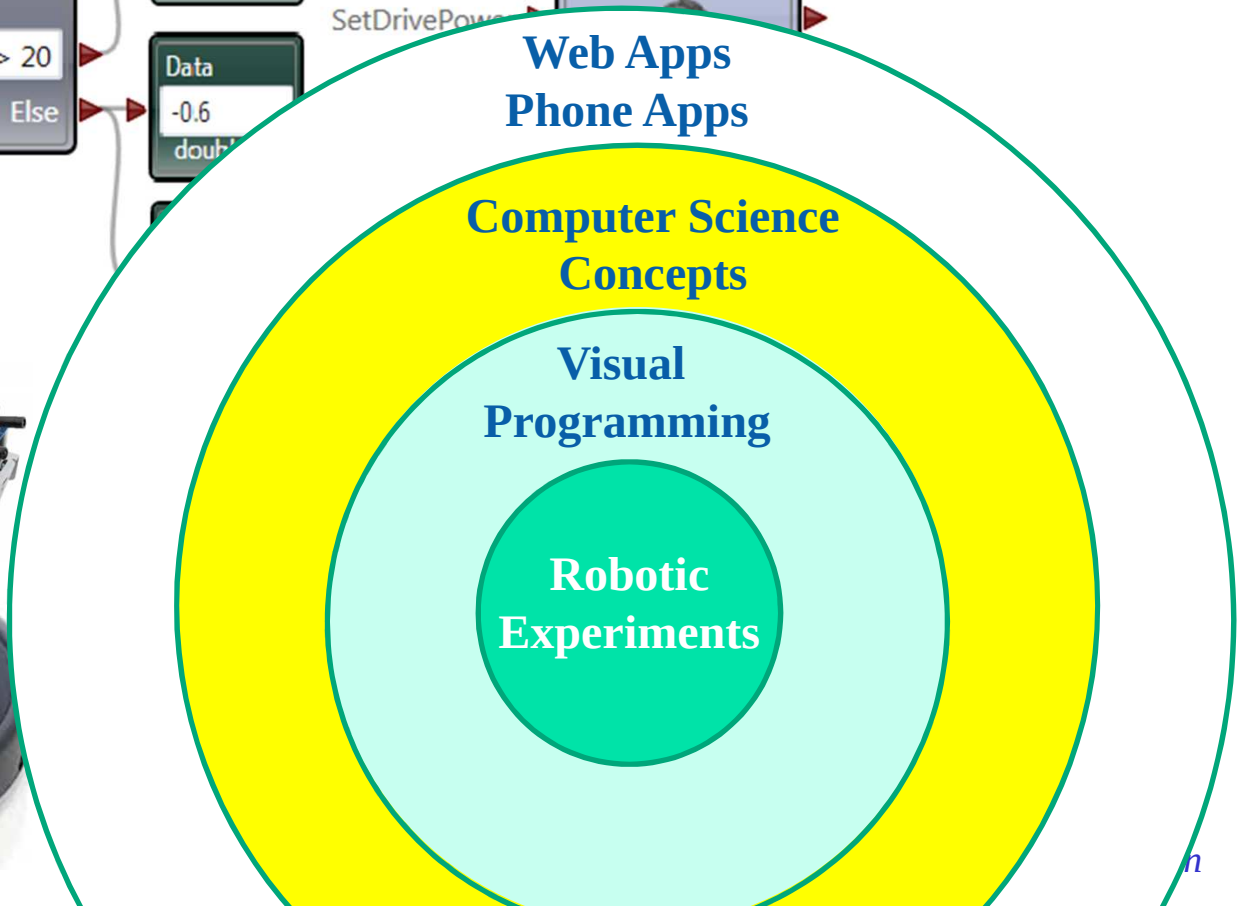
RaaS (Robot as a Service) is a cloud and Internet of Thing unit, consisting of Web Accessing Interface and Web-enabled mobile hardware

- Version 1, 2012 RaaS uses Intel Atom-based processor , with Parallax Hex Crawler Hardware
- Version 2, 2013, Cornell Cup, Using Web Programmable Interface
- Version 3, 2014 Intel Cup Shanghai, using Galileo and BayTrail,
- Version 4, 2015, Using Edison boards to build multiple robots. We are developing a new ASU Visual Programming Language, similar to Microsoft VPL, which can control RaaS over Internet

Before ASU IoT and RaaS

Microsoft VPL

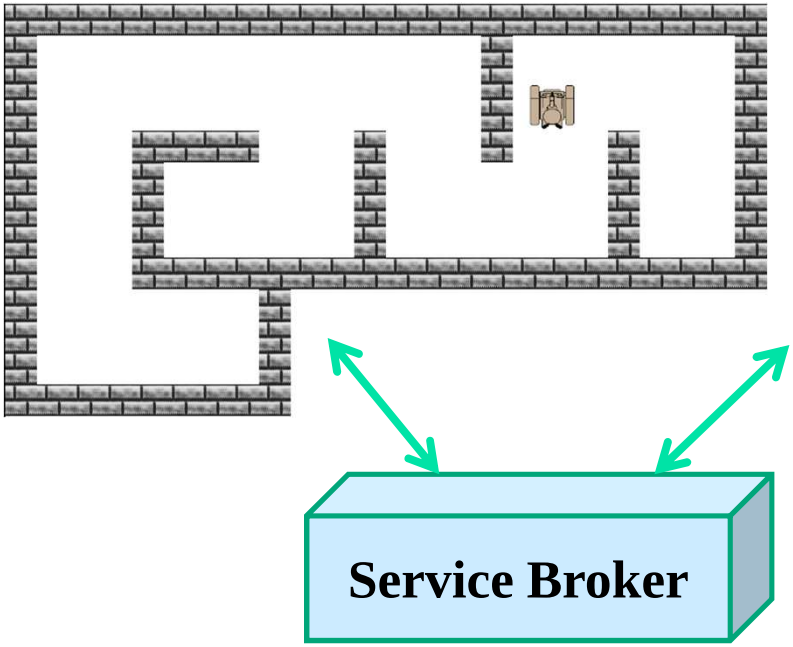




ASU IoT and RaaS Version 1, 2012

- **It is based on Intel Atom processor and Parallax Hex Crawler robot framework**
- **The first robot that is a full RaaS unit and is controllable over the Web:**
  http://venus.eas.asu.edu/WSRepository/RaaS/main/

Web Simulation Environment



Physical Robot

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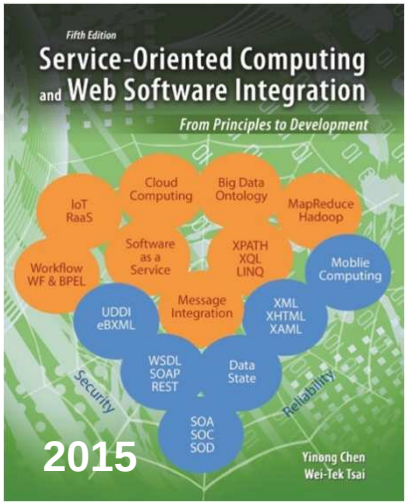
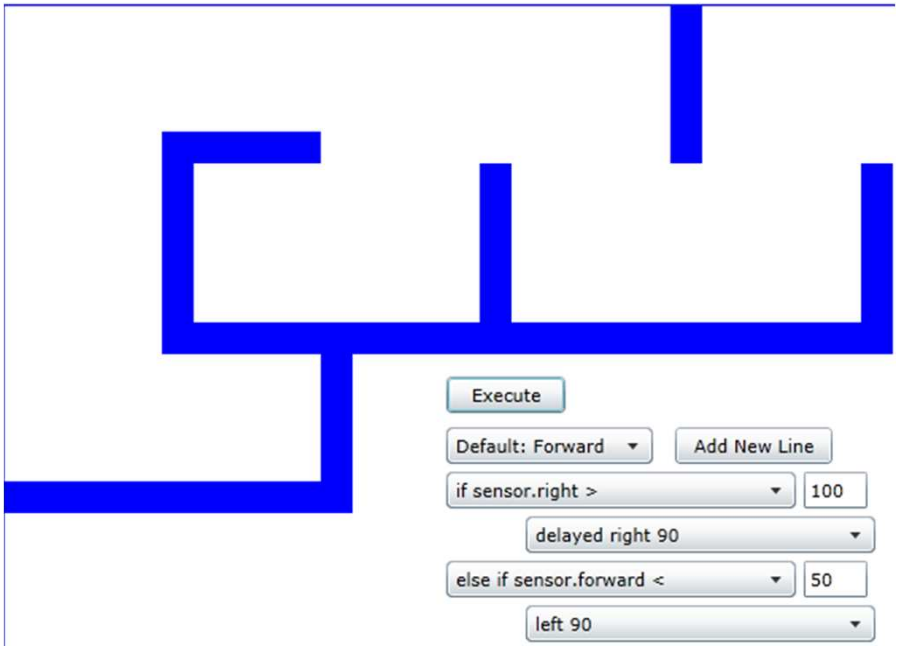
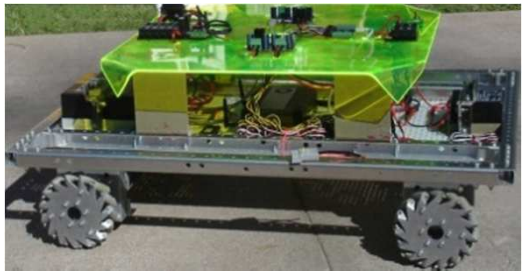
ASU IoT and RaaS Version 2, 2013



- **Cornell Cup Participant 2013**
- **The RaaS unit that can be programmed and controllable over the Web: http://venus.eas.asu.edu/WSRepository/eRobotic/**

Web Simulation & Programming Environment





Physical Robot

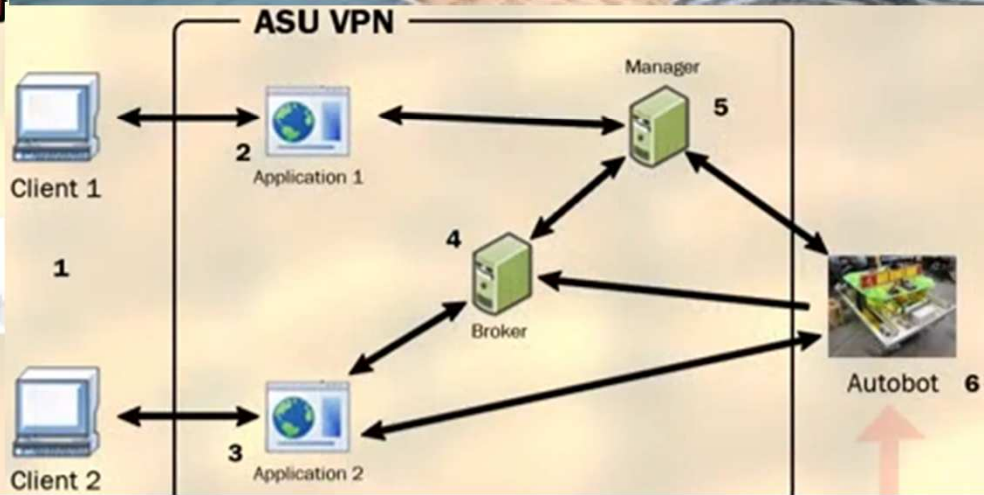
2013 Intel SINO-US
Intelligent Embedded System
Academic Workshop

August 21st-22nd,2013
Sichuan Province ,China

Intel-Based Robot

intel Education

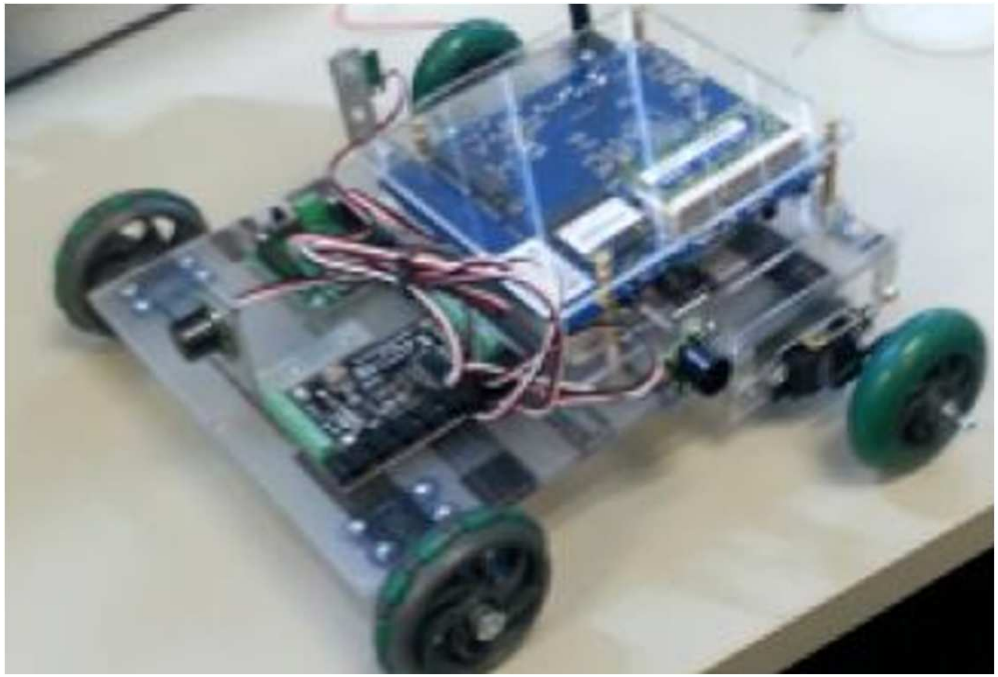
Cornell Cup: http://venus.eas.asu.edu/WSRepository/eRobotic/video2013.wmv



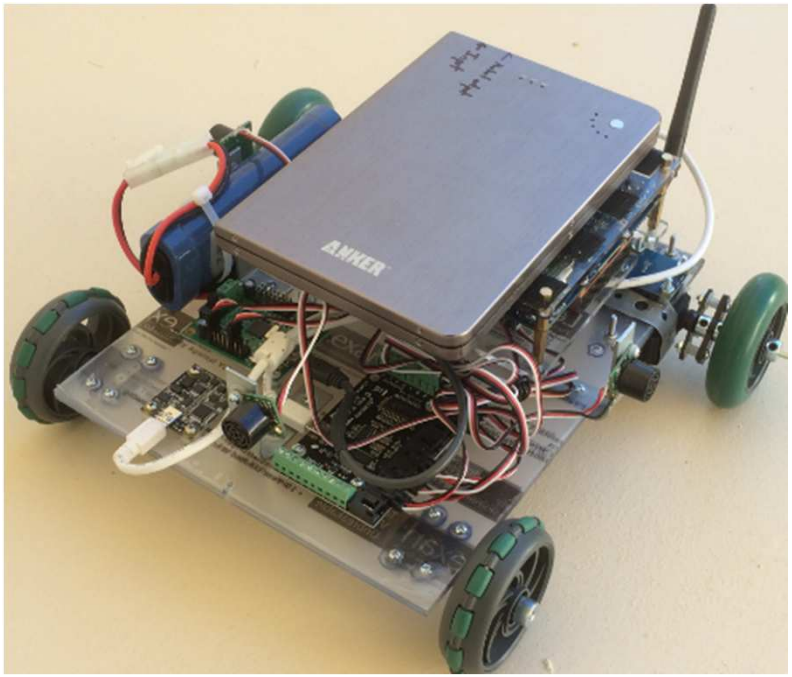
ASU IoT and RaaS Version 3 in 2014

- RaaS Hardware
  - Small robot better suitable for being used in large class.
    It is based on Quark and Atom;
  - The robot is an IoT unit;
- Software
  - The programming language is no longer Microsoft VPL. It is a Web-based graphic language – Made in ASU!
  - Program can control both simulated robot and physical robot.

ASU IoT and RaaS Version 3 2014 Hardware



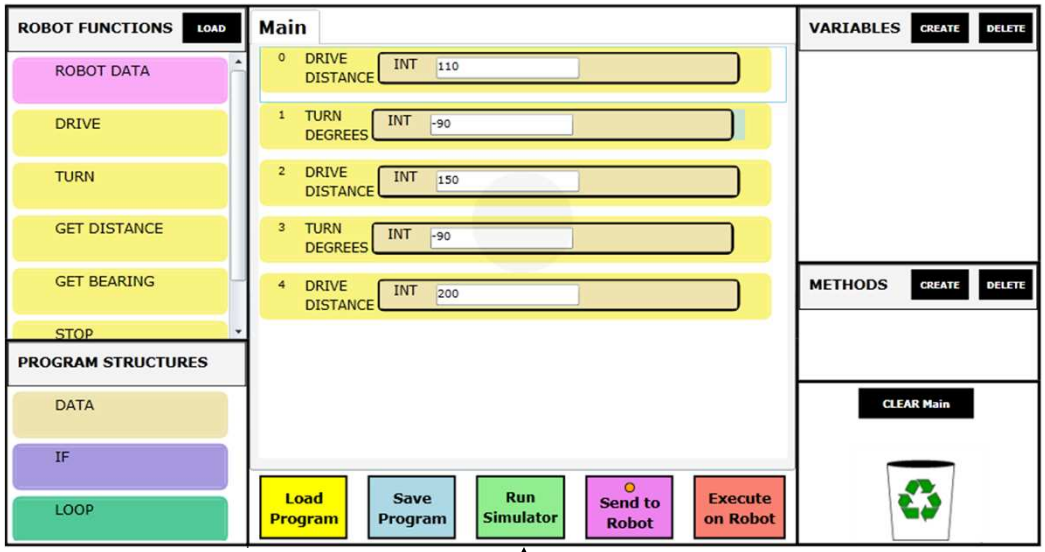
Galileo-based Version



Bay-Trail-based Version

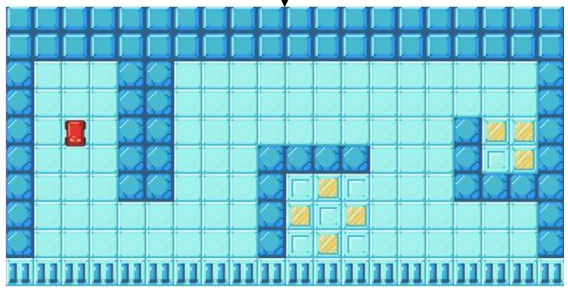
ASU IoT and RaaS Version 2014 System

Running in Web Browser

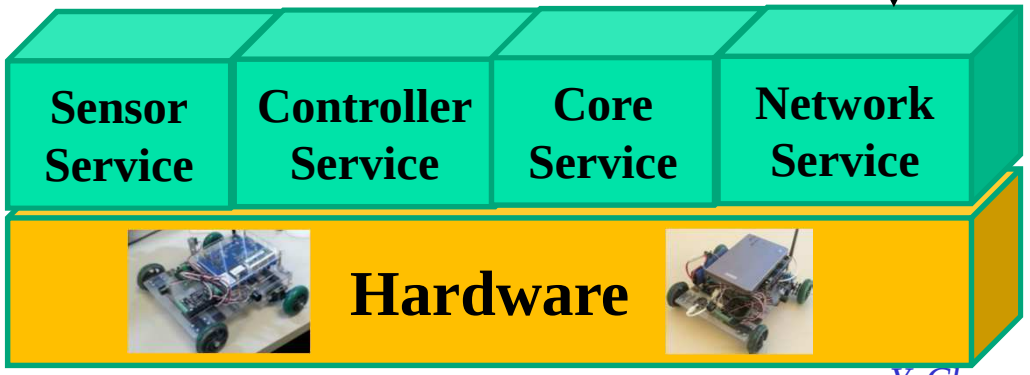


Web Service Broker

Simulator



Embedded software services



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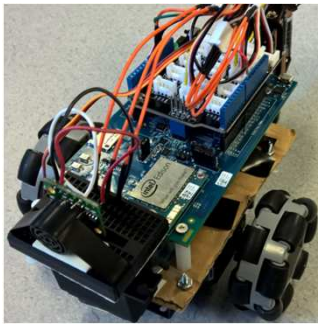
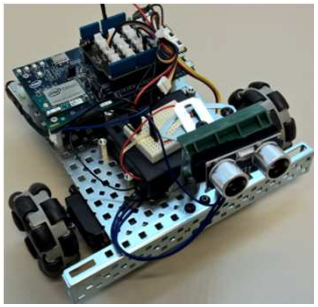
ASU IoT and RaaS Version 4 in 2015

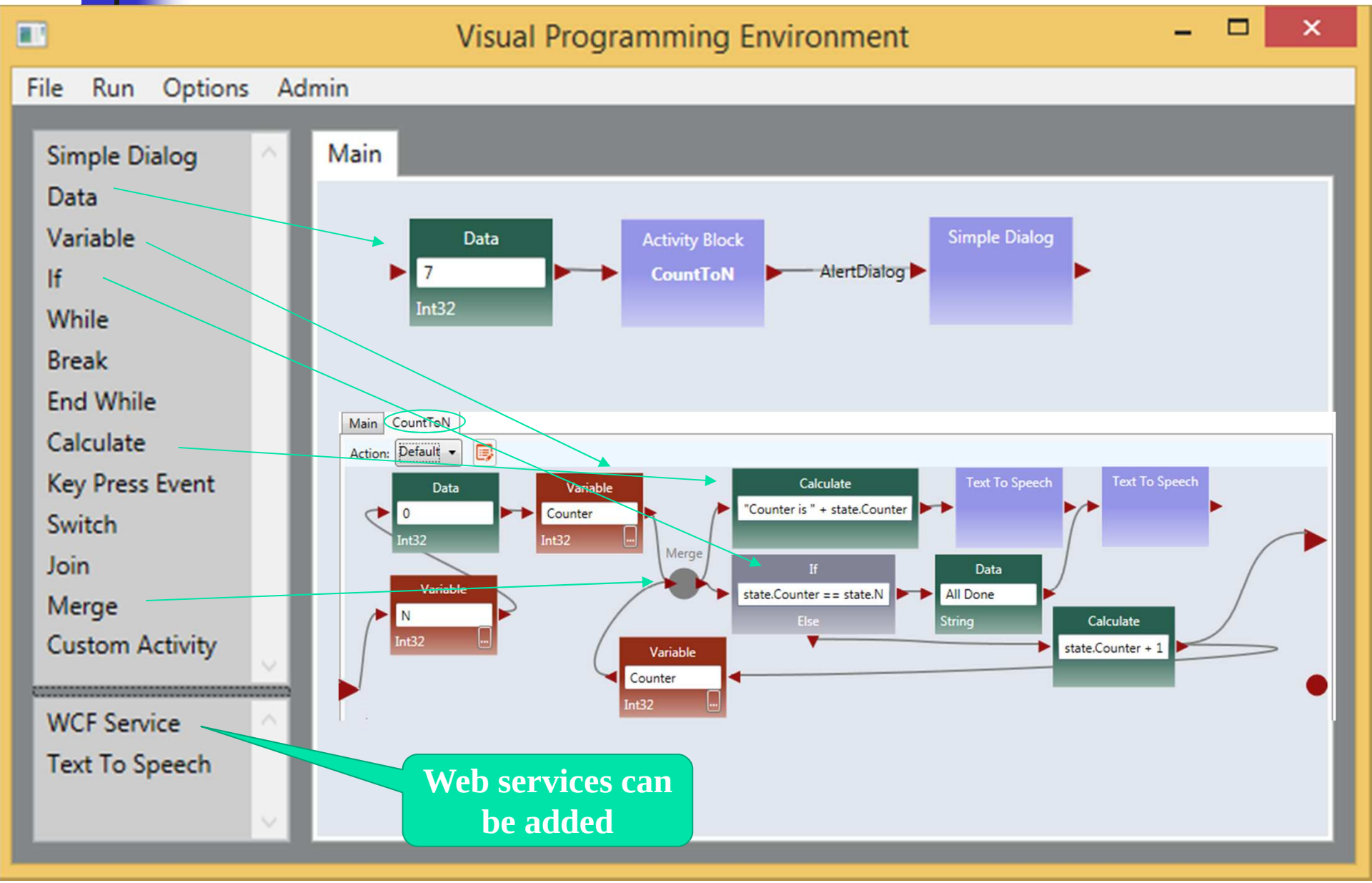
- **RaaS Hardware**
  - **The robot will be even smaller. It is based on Edison or Curie;**
  - **Multiple robots work together**

- **Software**
  - **A new software ASU-VPL**
  - **It does what Microsoft VPL does**
  - **It is a RaaS unit and connect to Internet**
  - **It connects our Intel-based robots**





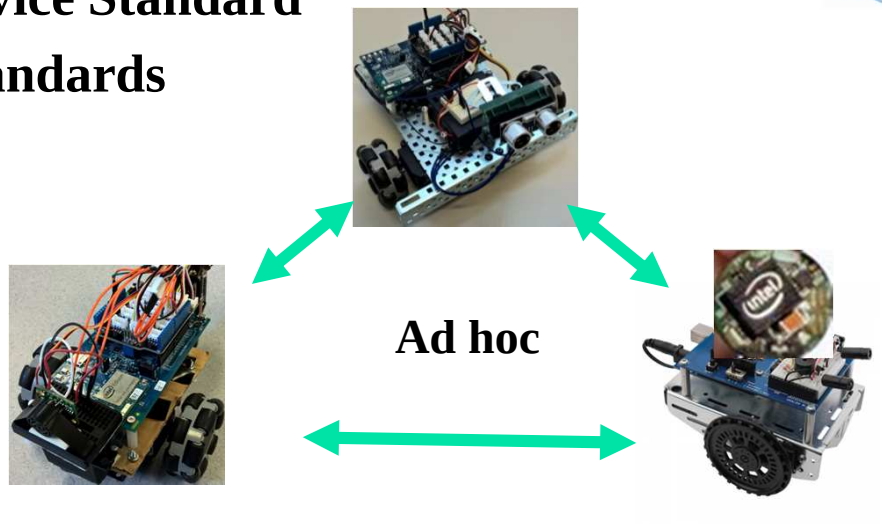
New ASU RaaS Software -- ASU VPL



ASU IoT and RaaS Version 4 Hardware

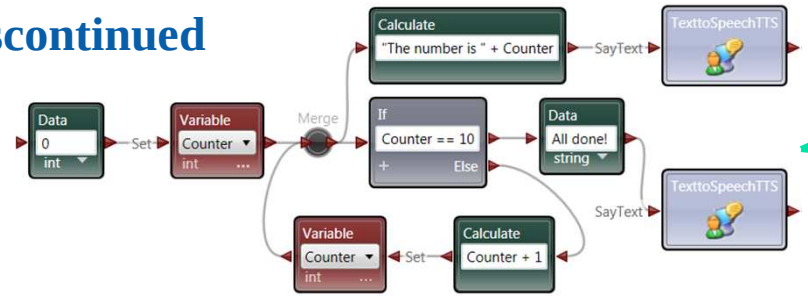
- **RaaS Hardware**
  - **Multiple robots collaboration**
  - **Ad hoc local communication**
  - **Infrastructure-based communication**
  - **Interoperability and standards**
    - **Web Service Standard**
    - **Other standards**

Infrastructure-based communication



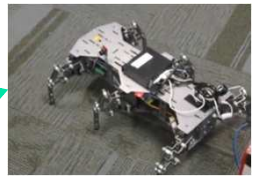
ASU IoT and RaaS Series in 2012 - 2015

Microsoft VPL Discontinued

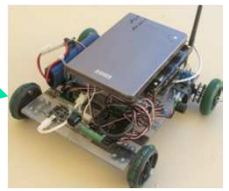


A Series of RaaS Robots

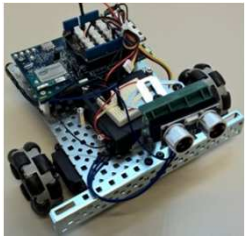
Largest



Large

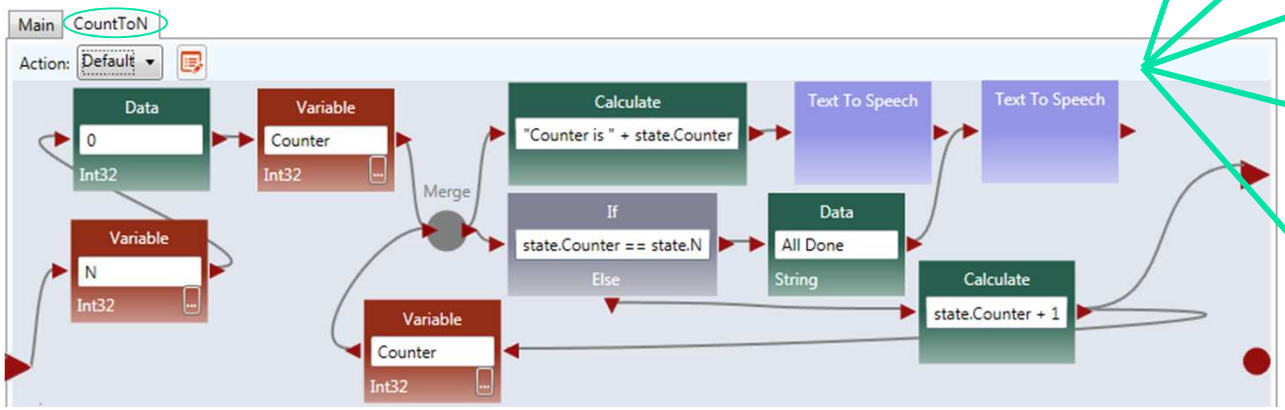


Small

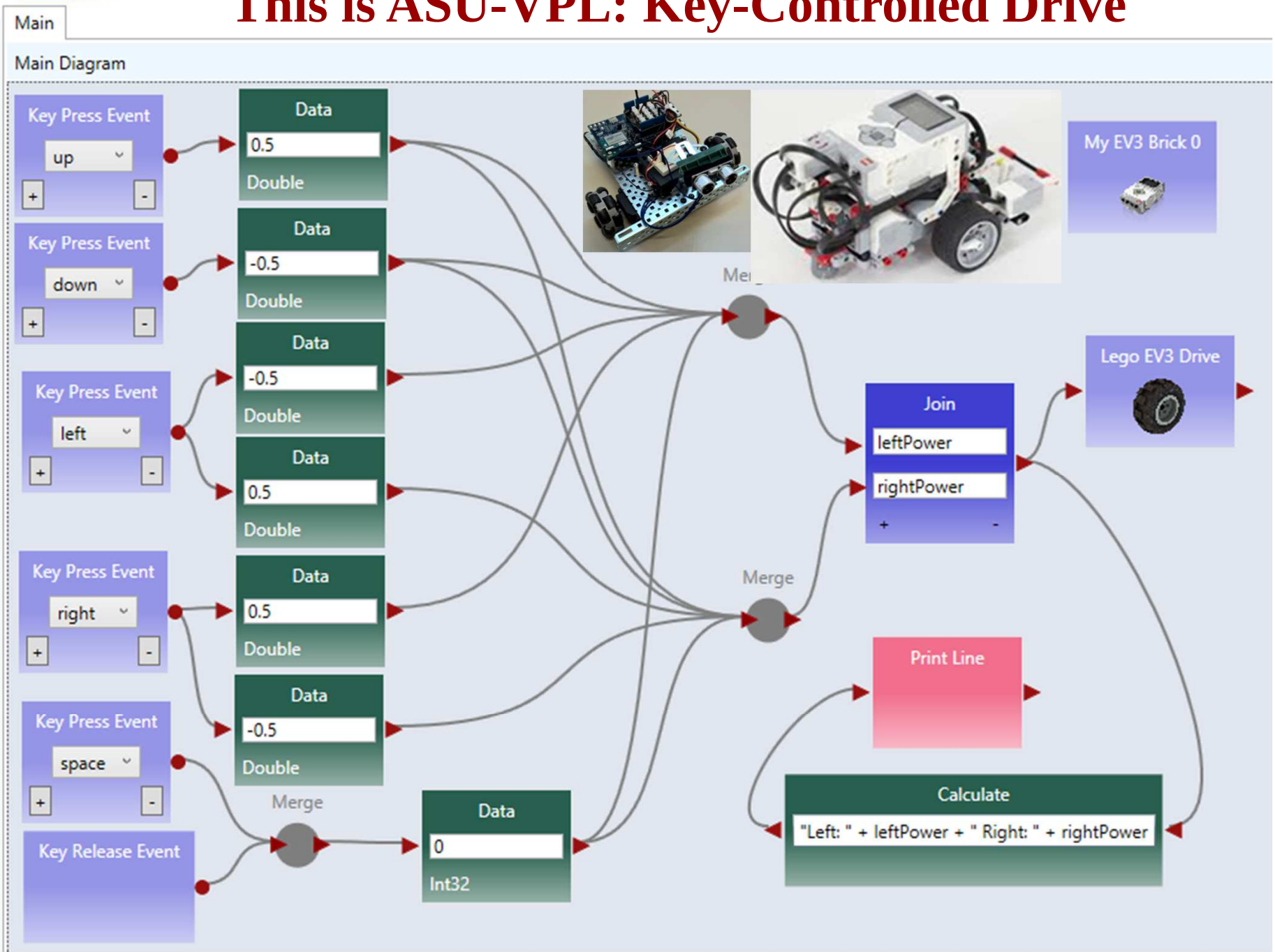


Smallest

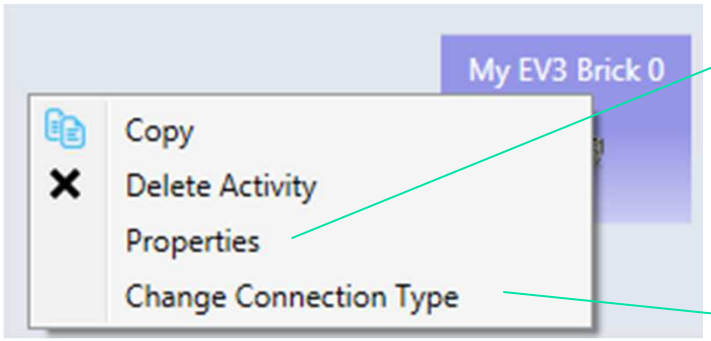
ASU VPL, making use of Microsoft VPL Skills

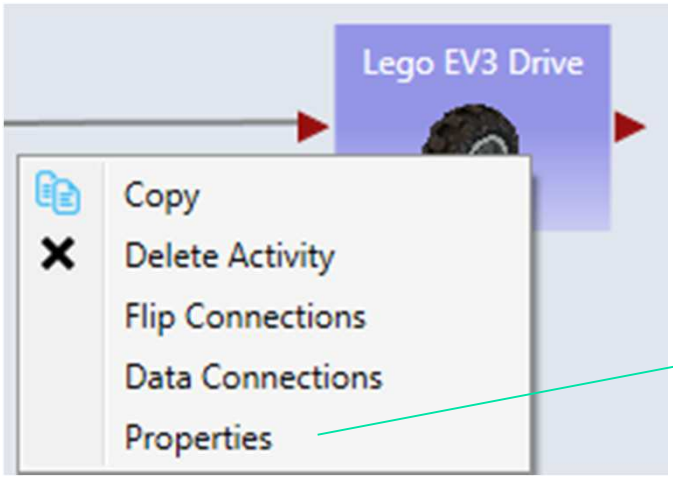


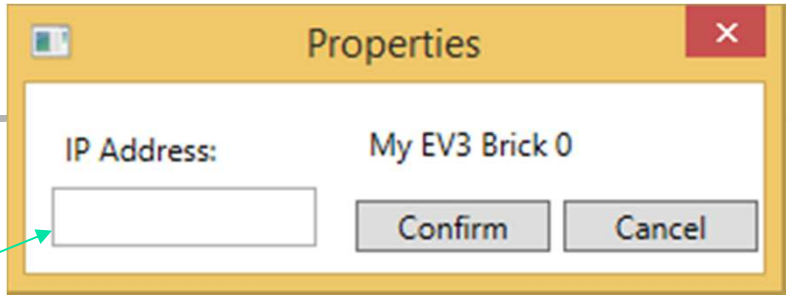
This is ASU-VPL: Key-Controlled Drive

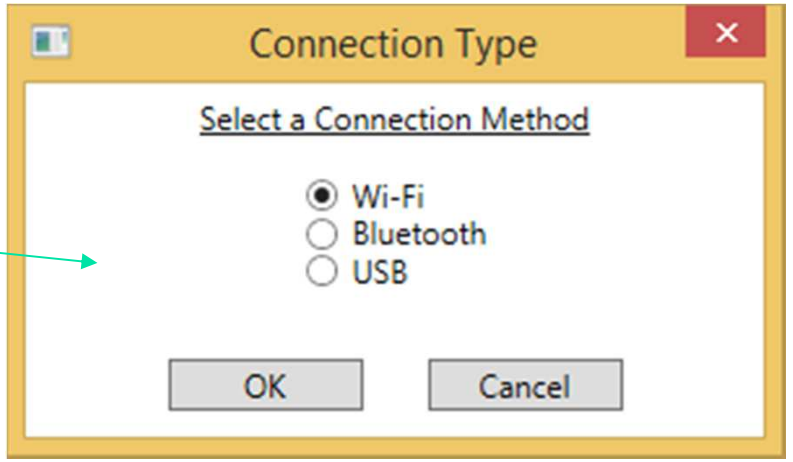


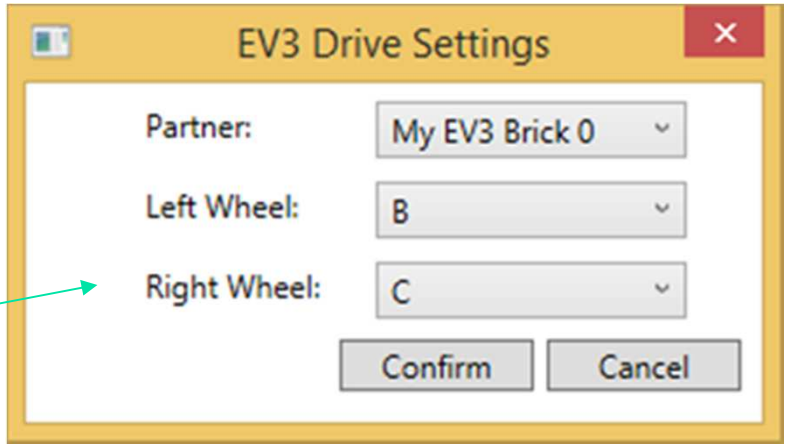
Configuration











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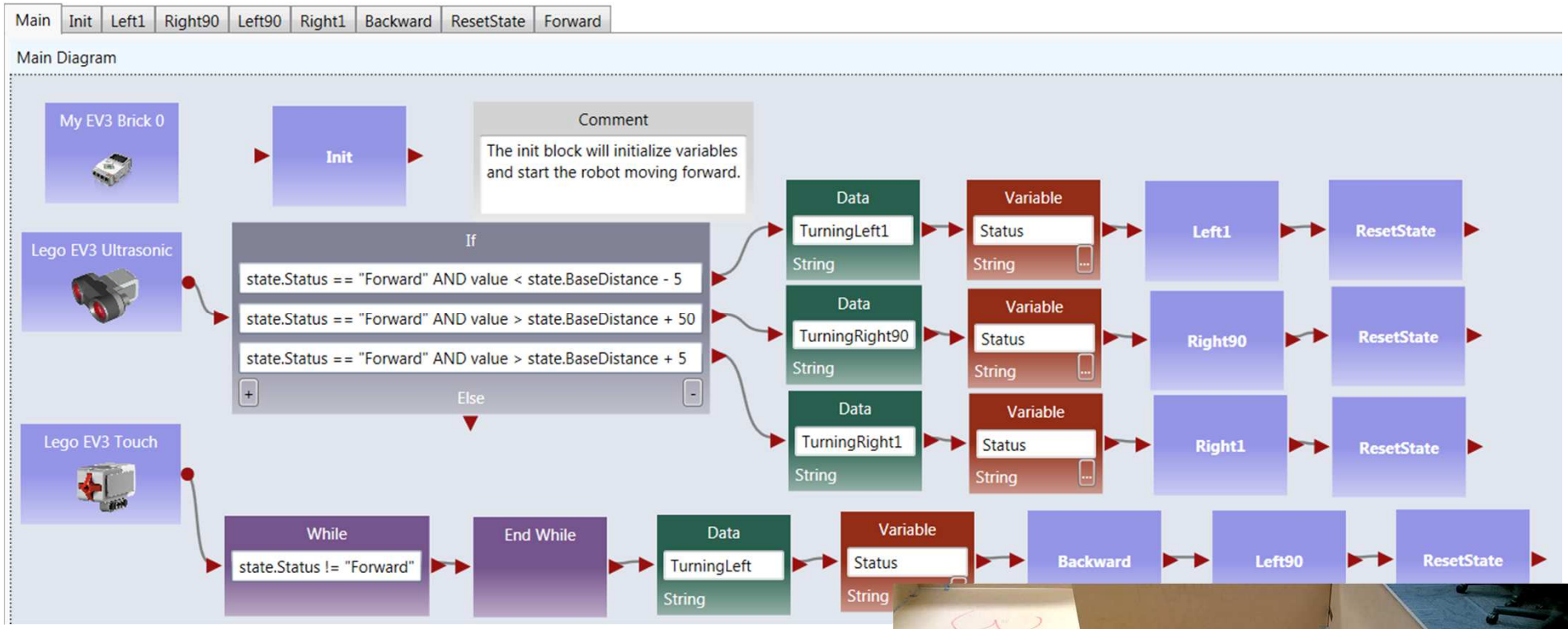
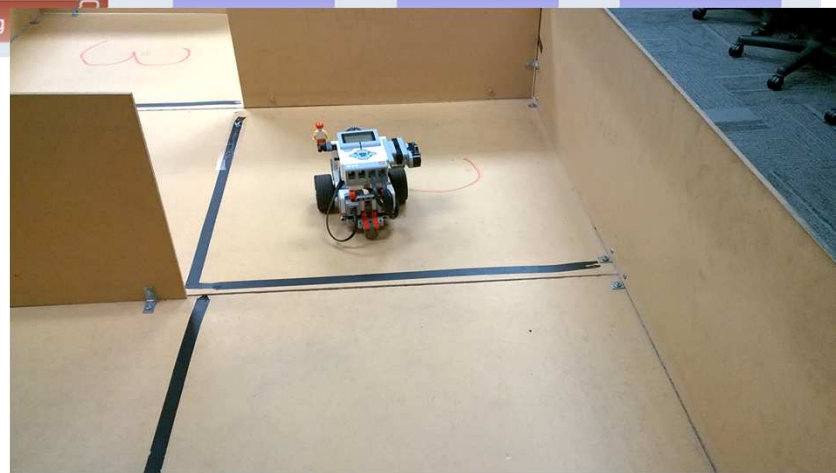
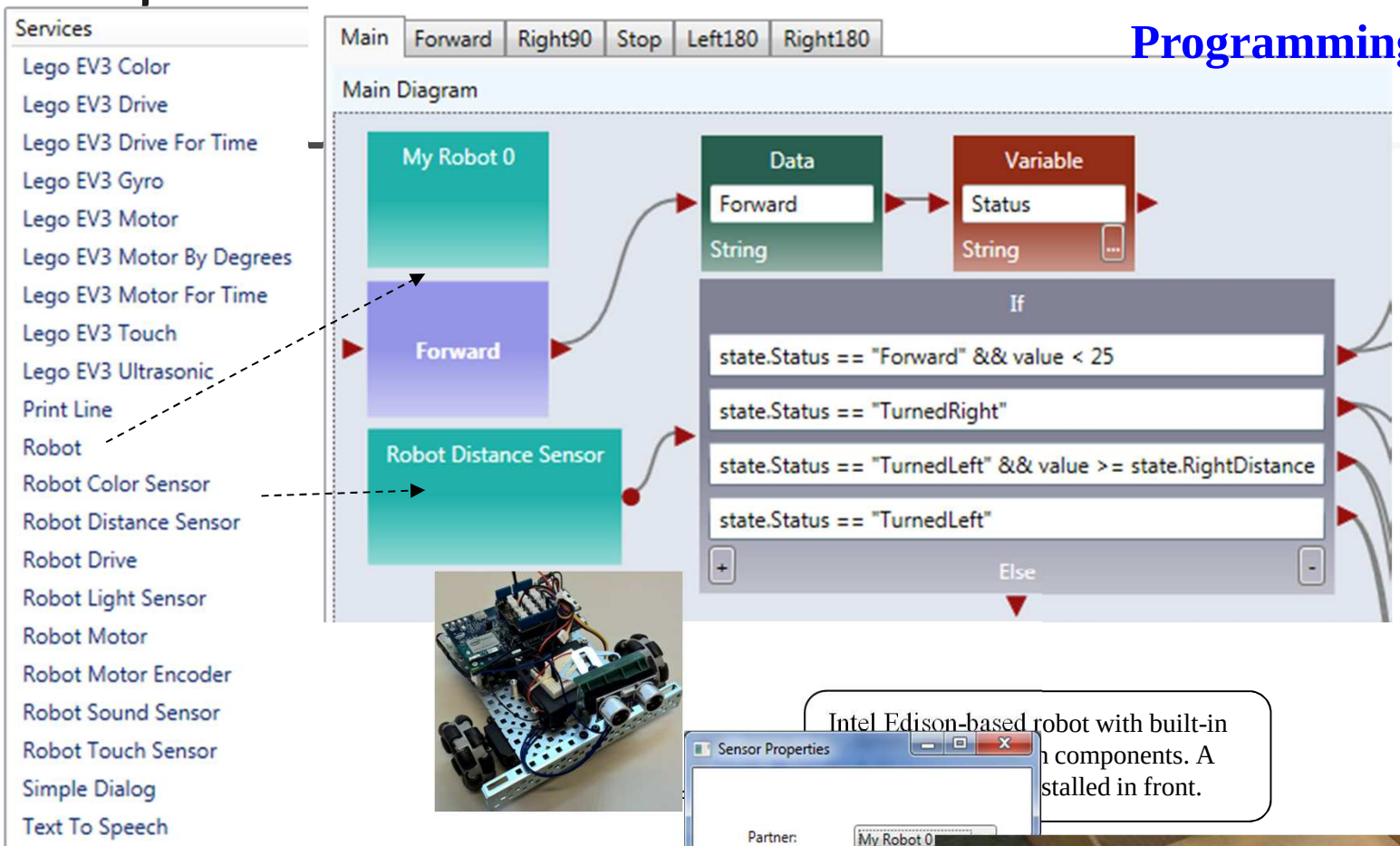
Right-Wall-Following Algorithm Using a Distance and a Touch Sensor

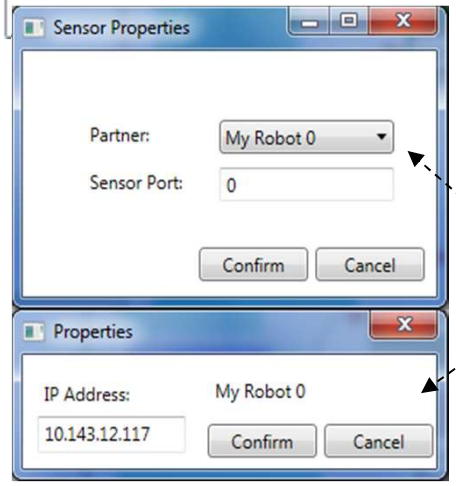


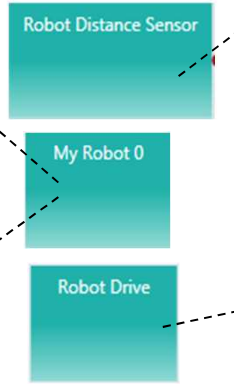


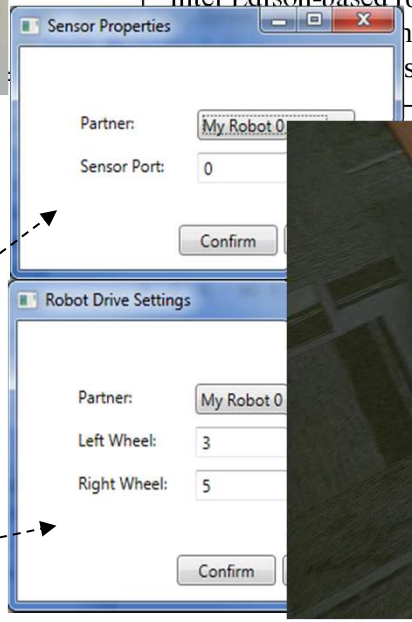
Programming Edison Robot

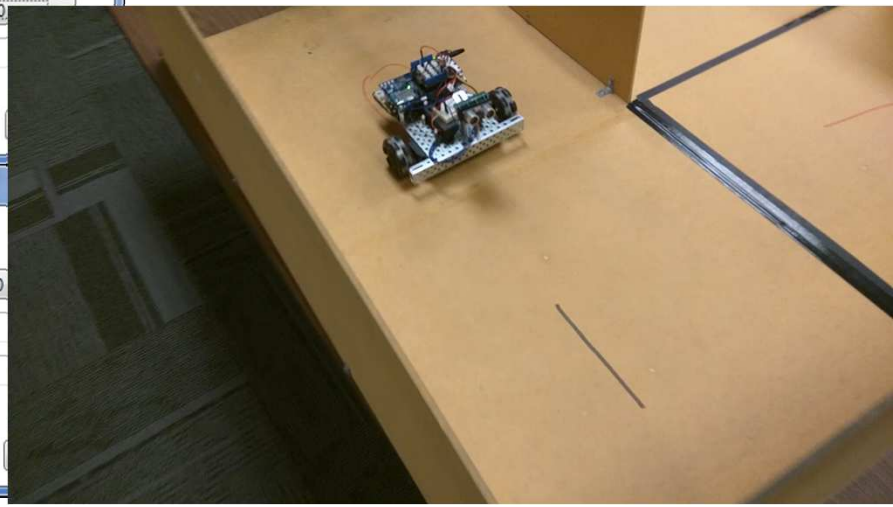


Intel Edison-based robot with built-in
components. A
stalled in front.









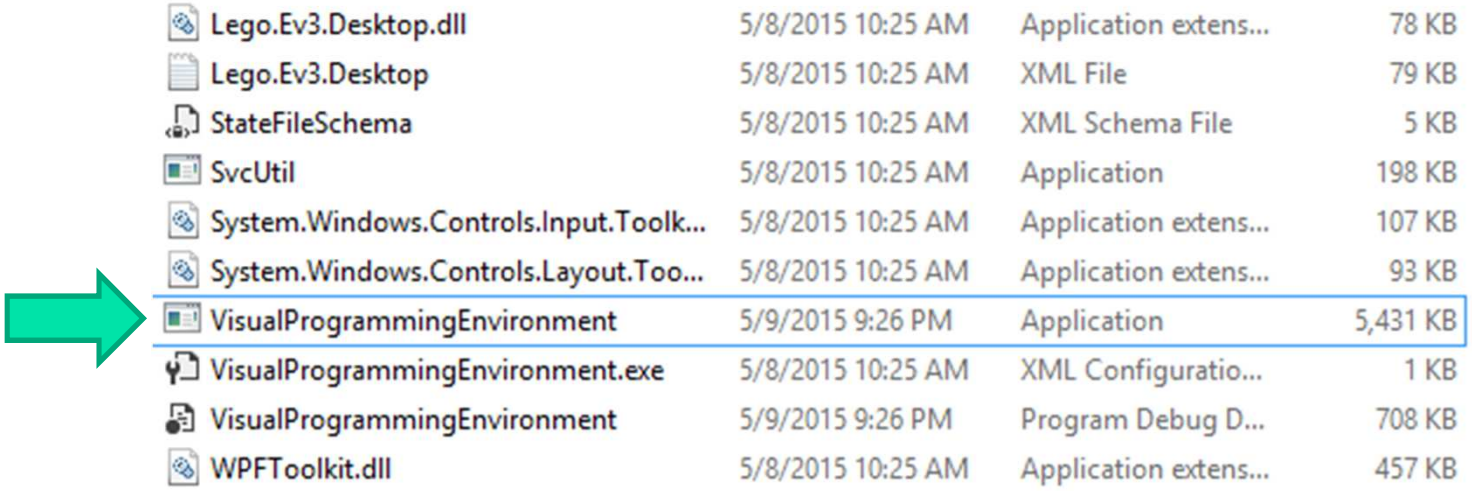
ASU-VPL Download for EV3 and Edison Robots

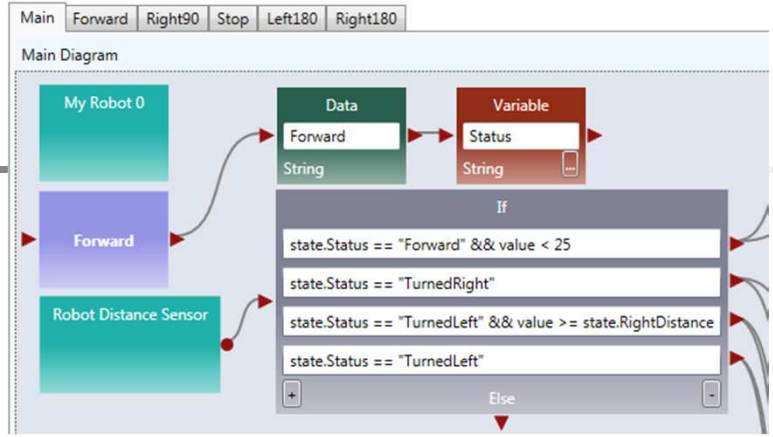
- **Download Link:**

  http://venus.eas.asu.edu/WSRepository/ASU-VPL/

- **Open the zip file:**

  1. **Samples;**
  2. **Release: Open the folder, start the application from the file: VisualProgrammingEnvironment**

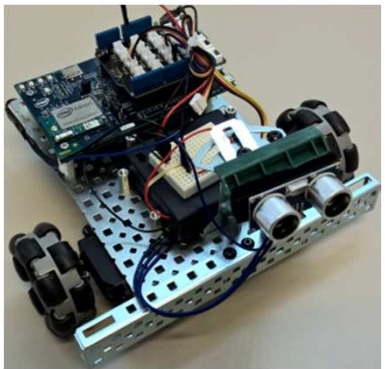


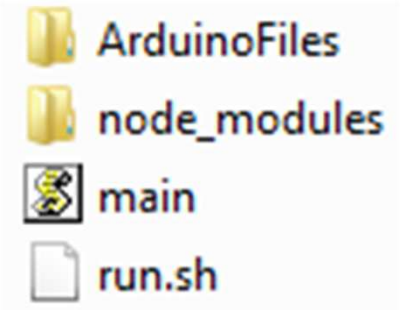


ASU-VPL Program on PC

```
ROBOT OUTPUT

name: string (touch, distance, sound, light, color, motorEncoder)
id: int
value: For touch sensor, value will be an int (0 = not pressed and 1 = pressed).
       For other sensors, value will be a double

{"sensors": [{"name":"touch", "id":0, "value":0},{"name":"distance", "id":0, "value":12.8}]}


ROBOT INPUT

servoId: int

servoSpeed: double between -1 and 1
 - negative values represent a backwards motion

{"servos": [{"servoId":3, “servoSpeed”:0.5},{"servoId":5, “servoSpeed”:-0.5}]}
```

JSON Object is a Web service data standard for communication





Code Running on Edison

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