NC STATE UNIVERSITY

ADAC

Intelligent Space (*i*Space) 2011

Mo-Yuen Chow

Advanced Diagnosis Automation and Control (ADAC) Lab

North Carolina State University

Raleigh, NC 27695

USA

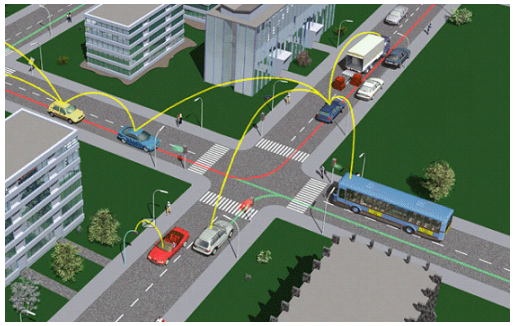
Outline

- iSpace
  - Introduction
  - iSpace at ADAC
    - Architecture
    - Distributed Sensors
    - Distributed Actuators
    - Distributed Controllers
    - Communication

iSpace - Introduction

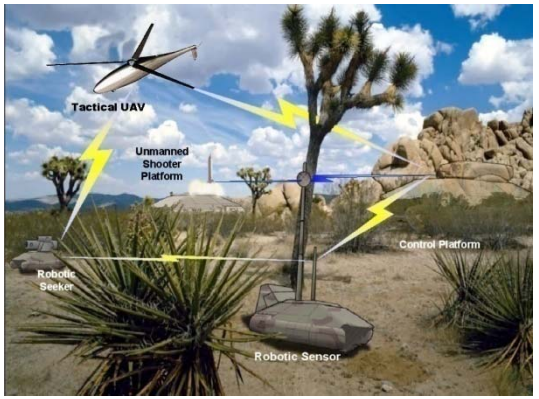
Definition: A new concept to effectively use distributed sensors, actuators, robots, computing processors, and information technology over a physically and/or virtually connected space. For example, a room, a corridor, a hospital, a factory, or a planet

Intelligent environments that are ***able to watch*** what their inhabitants are doing, ***build a model*** of them, ***communicate*** with them and ***act based on decisions*** they make.



Intelligent Transportation Systems

Telemedicine



Defense Systems

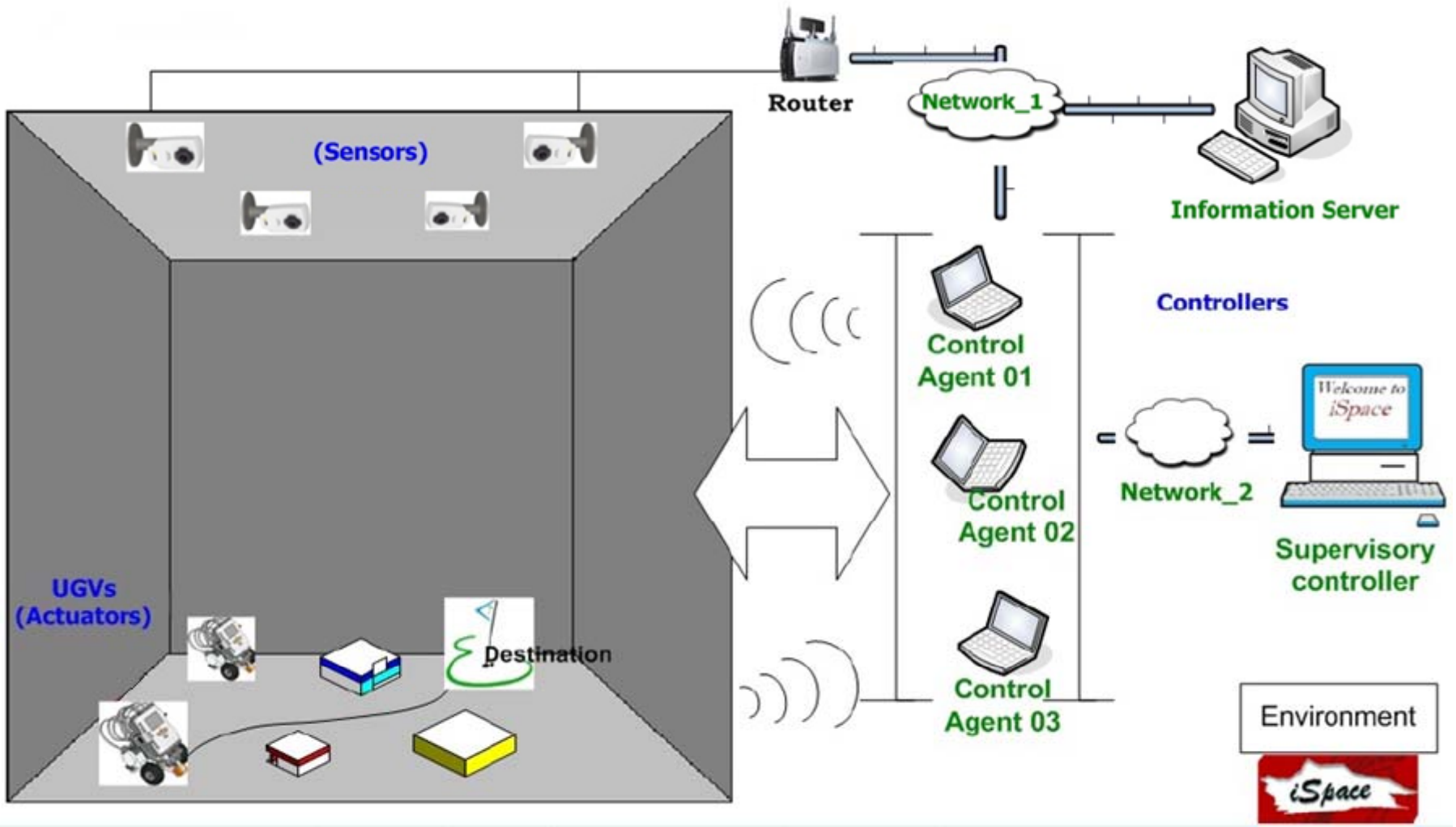
iSpace at ADAC

- iSpace at ADAC is a test platform for multi-robot control and distributed intelligent applications, such as intelligent transportation systems, distributed energy management and large scale resource allocation.
- Components
  - OptiTrack vision system
  - Multiple Lego robots
  - Supervisory and local controllers
  - Graphical user interface
- Features
  - Web enabled, wireless control, modular
  - Network delay/noise simulator
  - Different control and resource allocation algorithms

NC STATE UNIVERSITY

iSpace at ADAC

ADAC



NC STATE UNIVERSITY

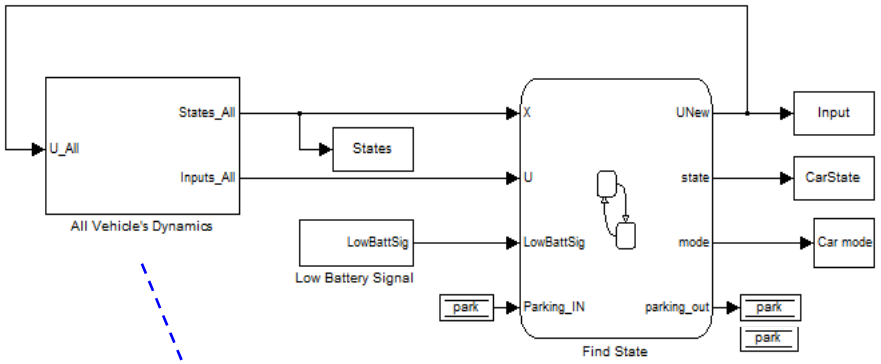
iSpace at ADAC

ADAC

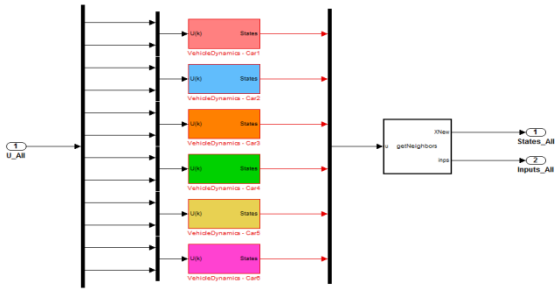
NC STATE UNIVERSITY

iSpace Simulator

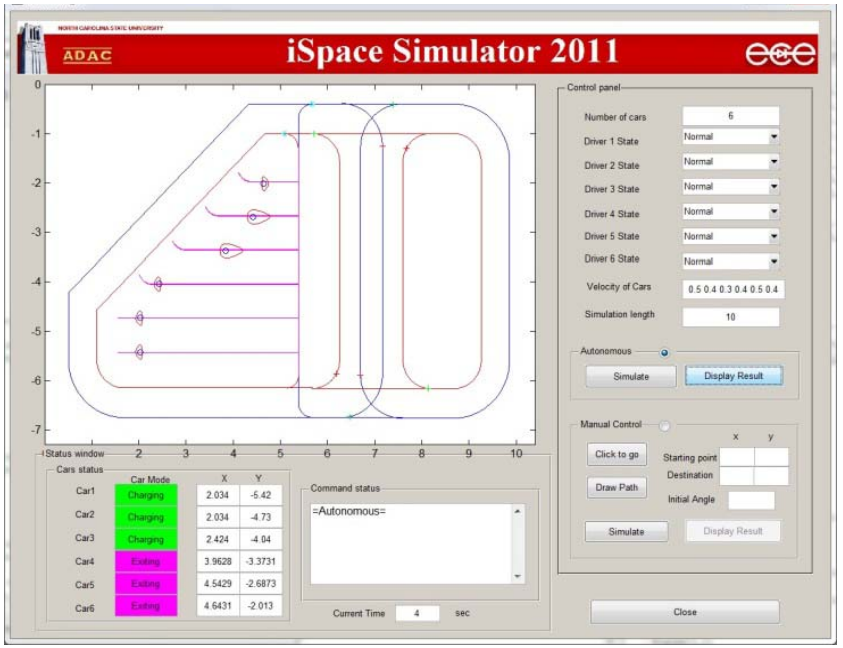
ADAC



iSpace Simulator

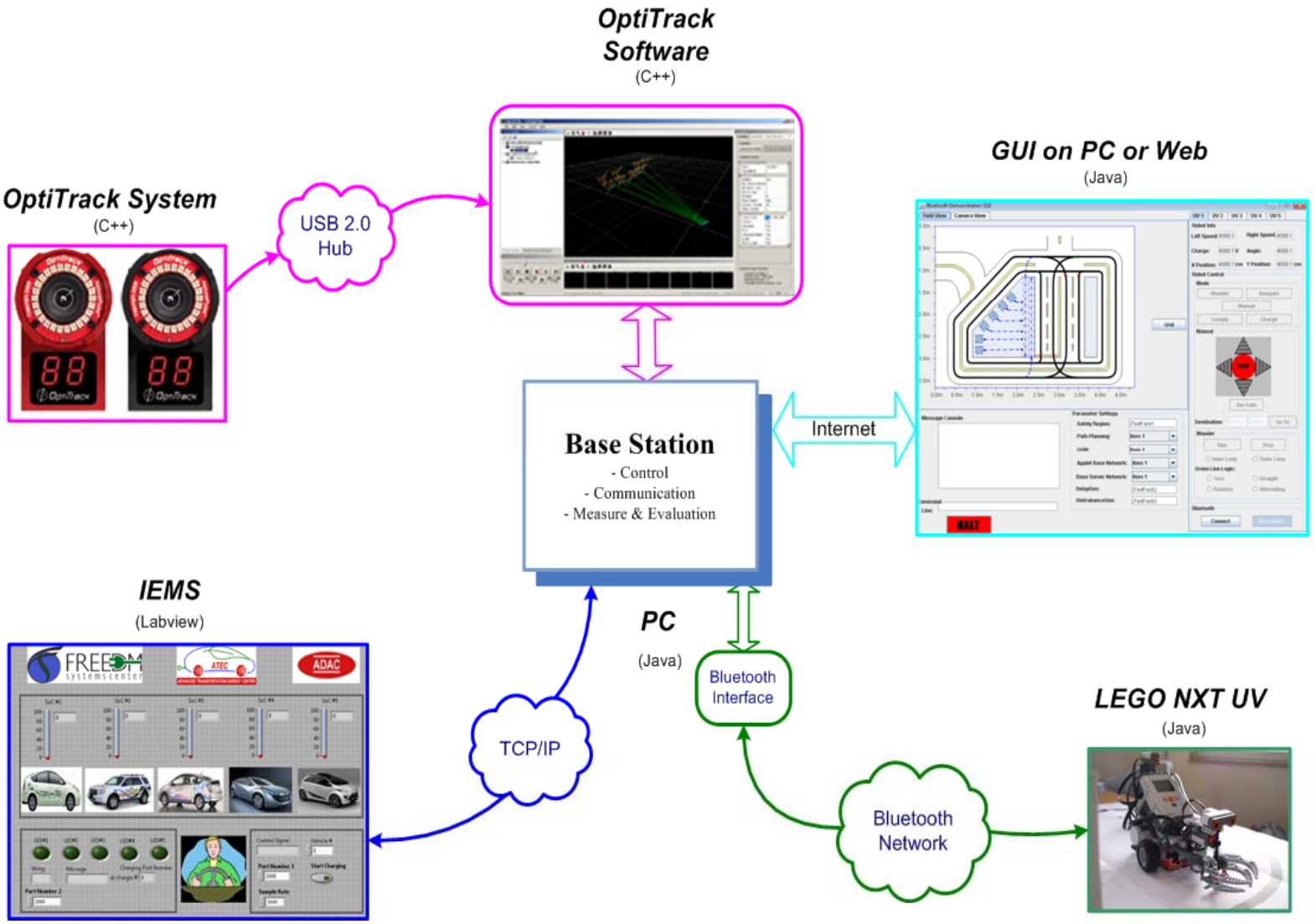


Robot Dynamics



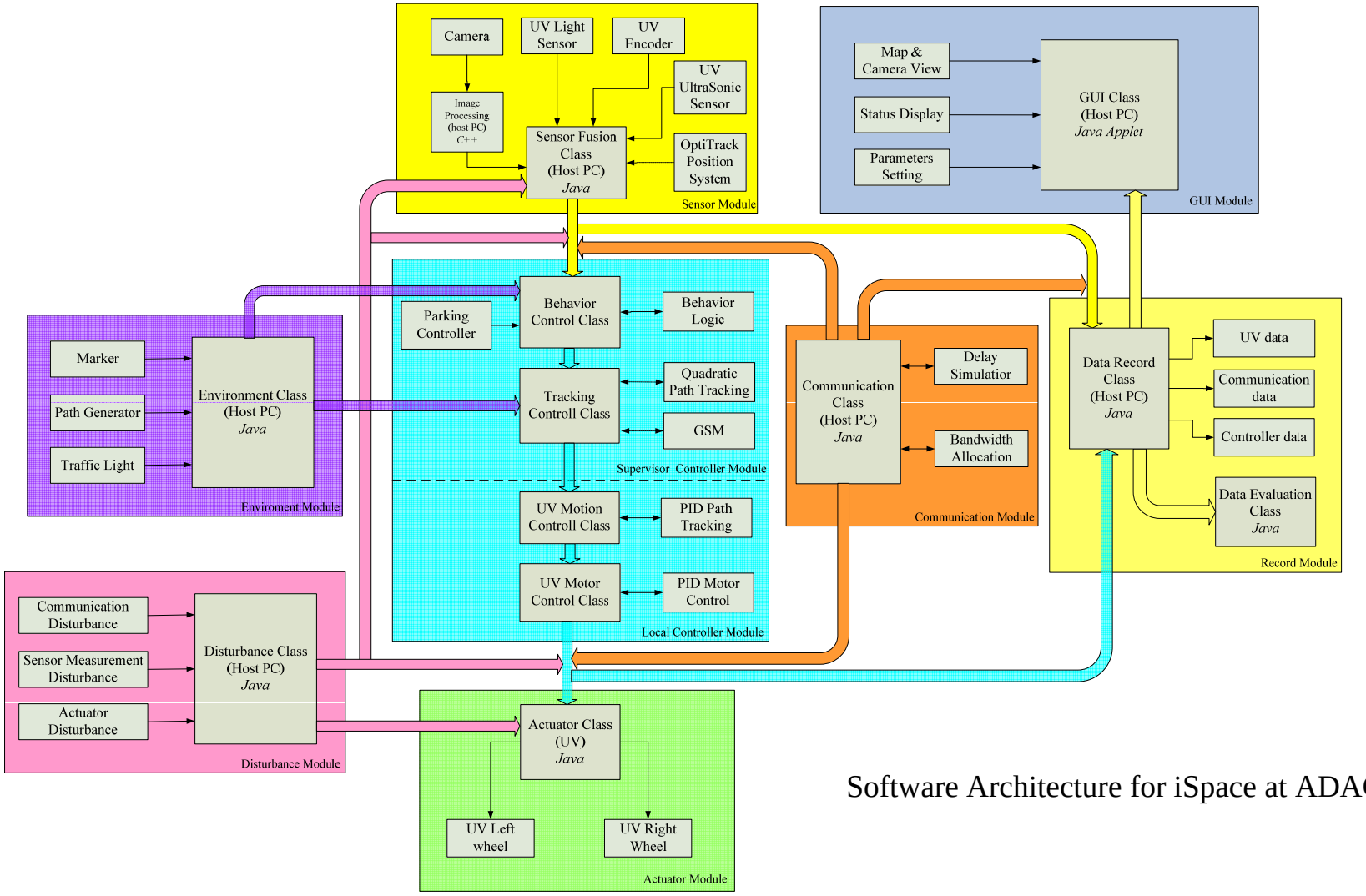
Simulator GUI

iSpace at ADAC Architecture



Hardware Architecture for iSpace at ADAC

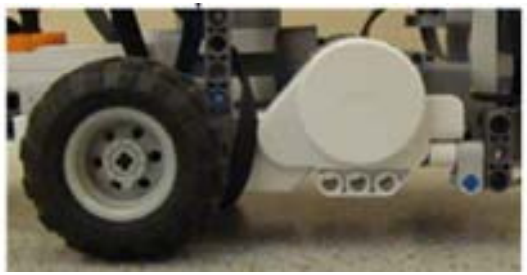
iSpace at ADAC Architecture



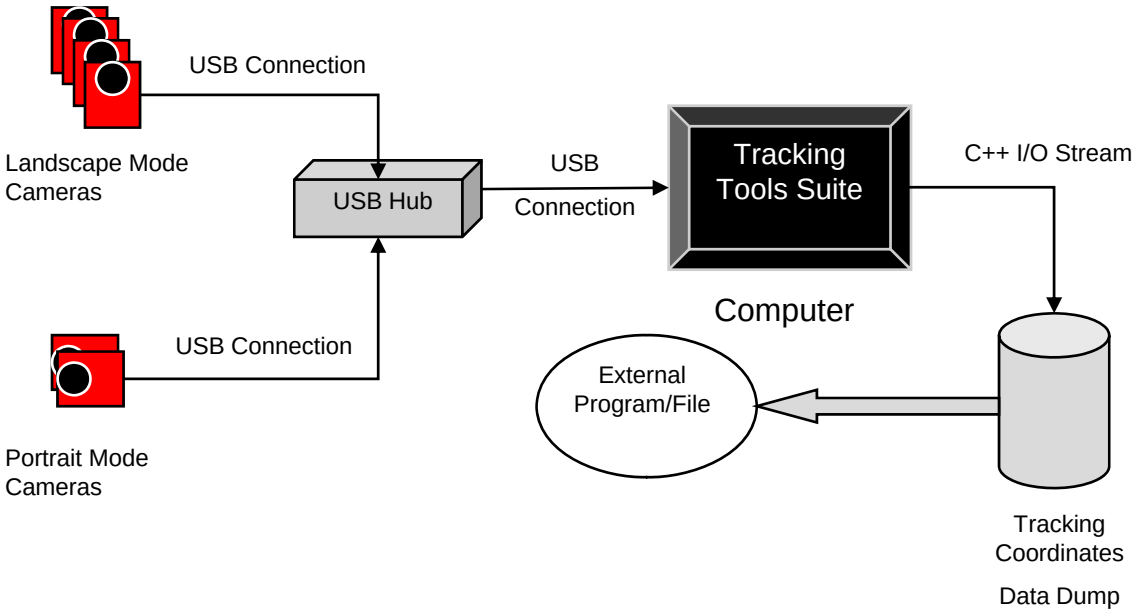
Software Architecture for iSpace at ADAC

iSpace at ADAC Distributed Sensors

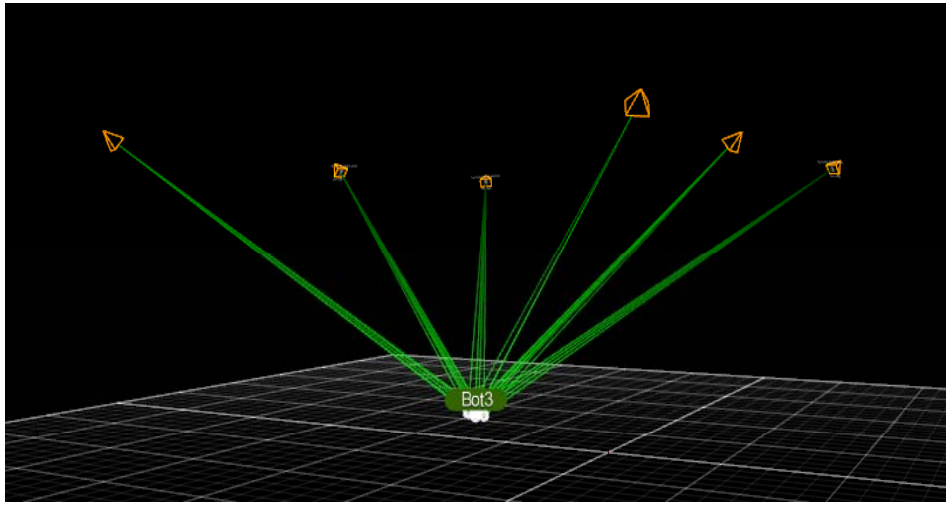
- Vision system and Rotary encoders act as the distributed sensors in iSpace
- Vision system is used for global information about the objects in iSpace, e.g. absolute (x, y) coordinates of the robots
  - iSpace at ADAC uses OptiTrack system for all vision processing tasks
  - OptiTrack is a hardware and software system that is capable of tracking rigid bodies in real time.
  - Small markers configured in distinct patterns on the vehicles reflect the infrared light emitted from the cameras.
- Rotary encoders used for local information e.g. relative position of a robot



iSpace at ADAC Distributed Sensors



- Each camera finds the distance to the marker based on the perceived size
- Three cameras allow the system to triangulate the position in 3D space

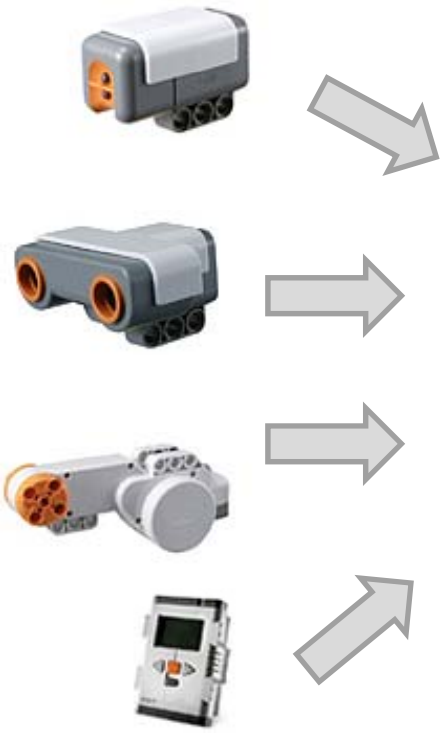


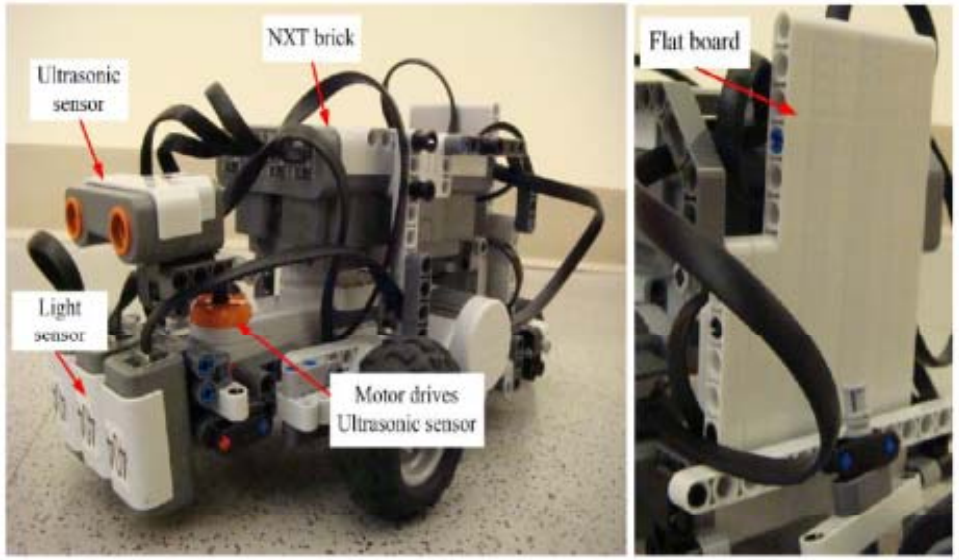
NC STATE UNIVERSITY

iSpace at ADAC Distributed Actuators

ADAC

- Lego robots act as the distributed actuators in iSpace
- LEJOS Java for Mindstorms is used to program the robots





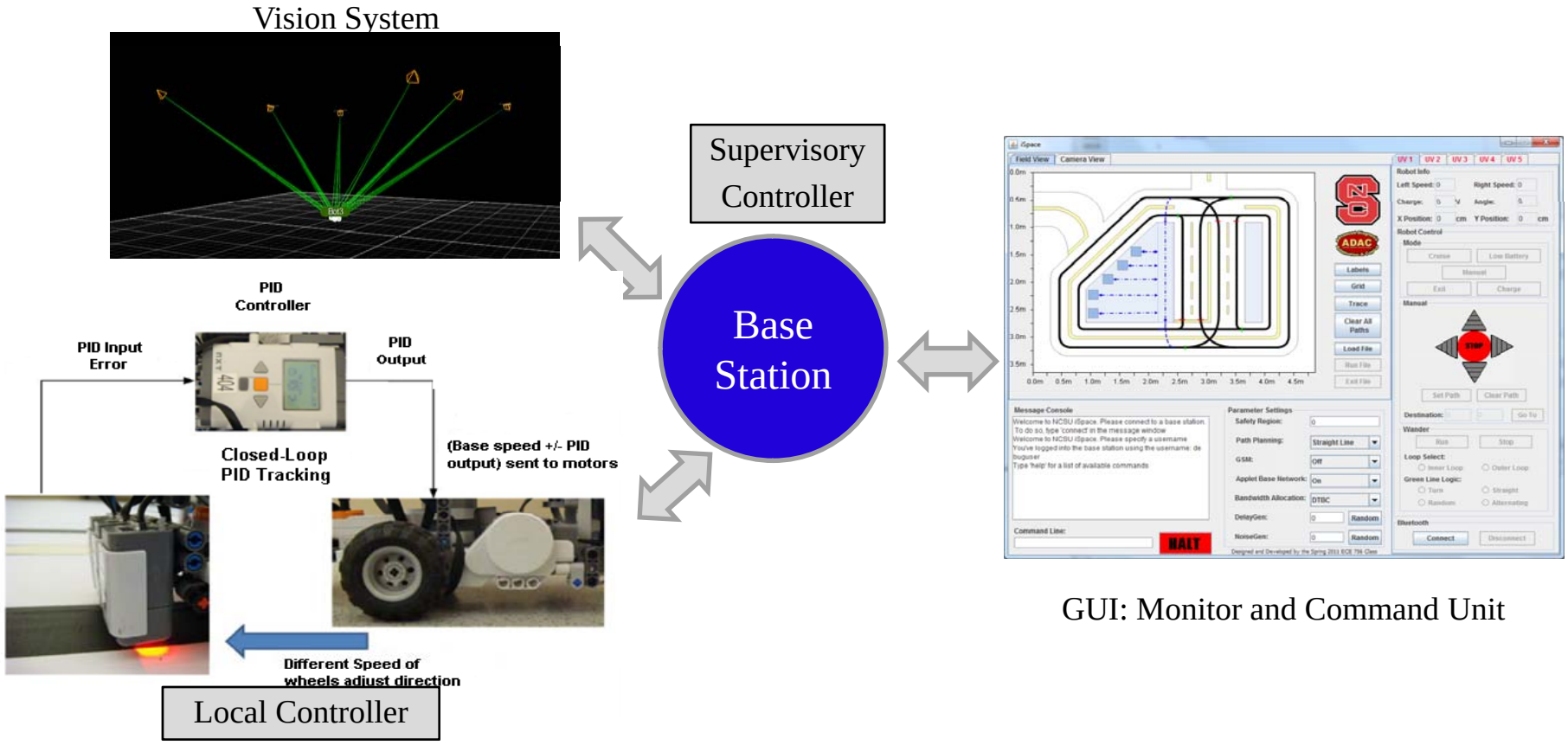
LEJOS
Java for LEGO Mindstorms

NC STATE UNIVERSITY

iSpace at ADAC Distributed Controllers

ADAC

- Distributed controllers fuse the information from sensors to make real-time decisions
  - Can be individual decision controller or collaborative decision controller

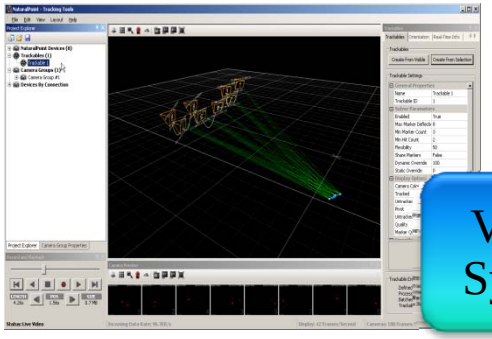


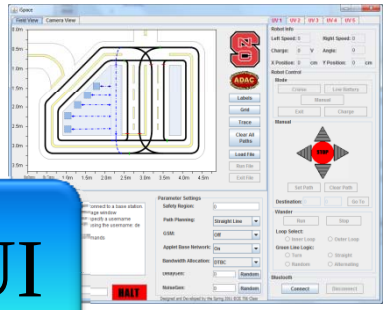
NC STATE UNIVERSITY

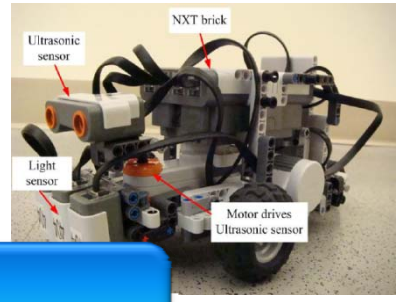
iSpace at ADAC Communication

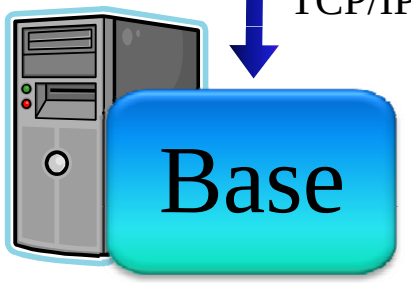
ADAC

- Vision system, GUI, and base station communicate over TCP/IP
- Robots communicate wirelessly with base station using Bluetooth



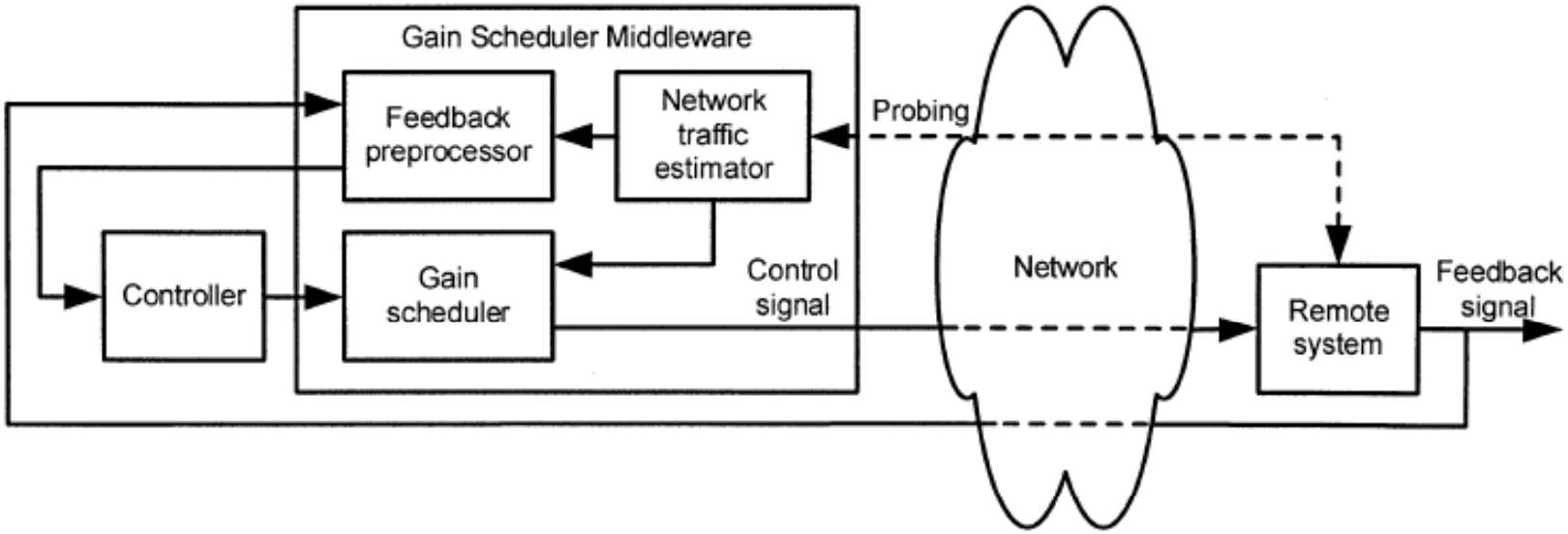




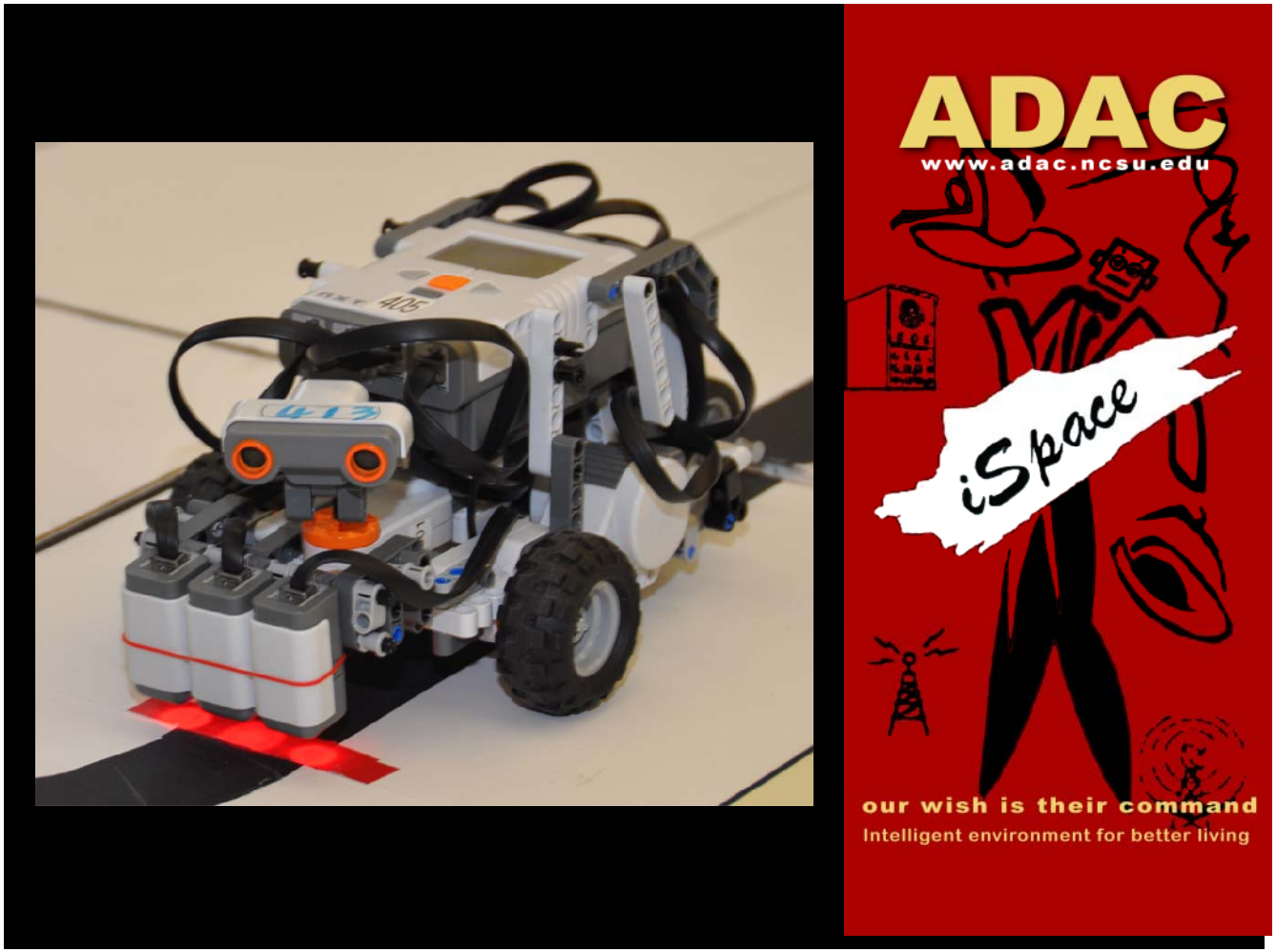


iSpace at ADAC Algorithms

- Path generation and tracking
  - Fast marching method, Quadratic curve path tracking algorithm
- Network delay compensation
  - Gain Scheduling Middleware, Predictive Control Gain Scheduling
- Bandwidth allocation
  - Behavior Control based, delay tolerant



iSpace at ADAC Video Demo



http://www.youtube.com/watch?v=MAkdWW3IbYA

Thank you!

Acknowledgements: This work is partially supported by the National Science Foundation (NSF) under Award Number NSF-ECS-0823952 “AIS Gene Library based Resource Allocation for Large Scale Time-Sensitive Multi-Rate Systems” .