Team Project Demonstration: A Surveillant Robot System

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Little Red Team

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Agenda

- Team Introduction
- Task plan
- Our system life cycle
- Our task plan
- System requirements
- System Design
- Four important features
- Used S/W & H/W technologies
- Difficulties and Constraints
- S/W & H/W introduction
- Demo Environment
  - Layout of demo room
- Future Consideration
- Lesson learned

Team Intro.– Little Red Team

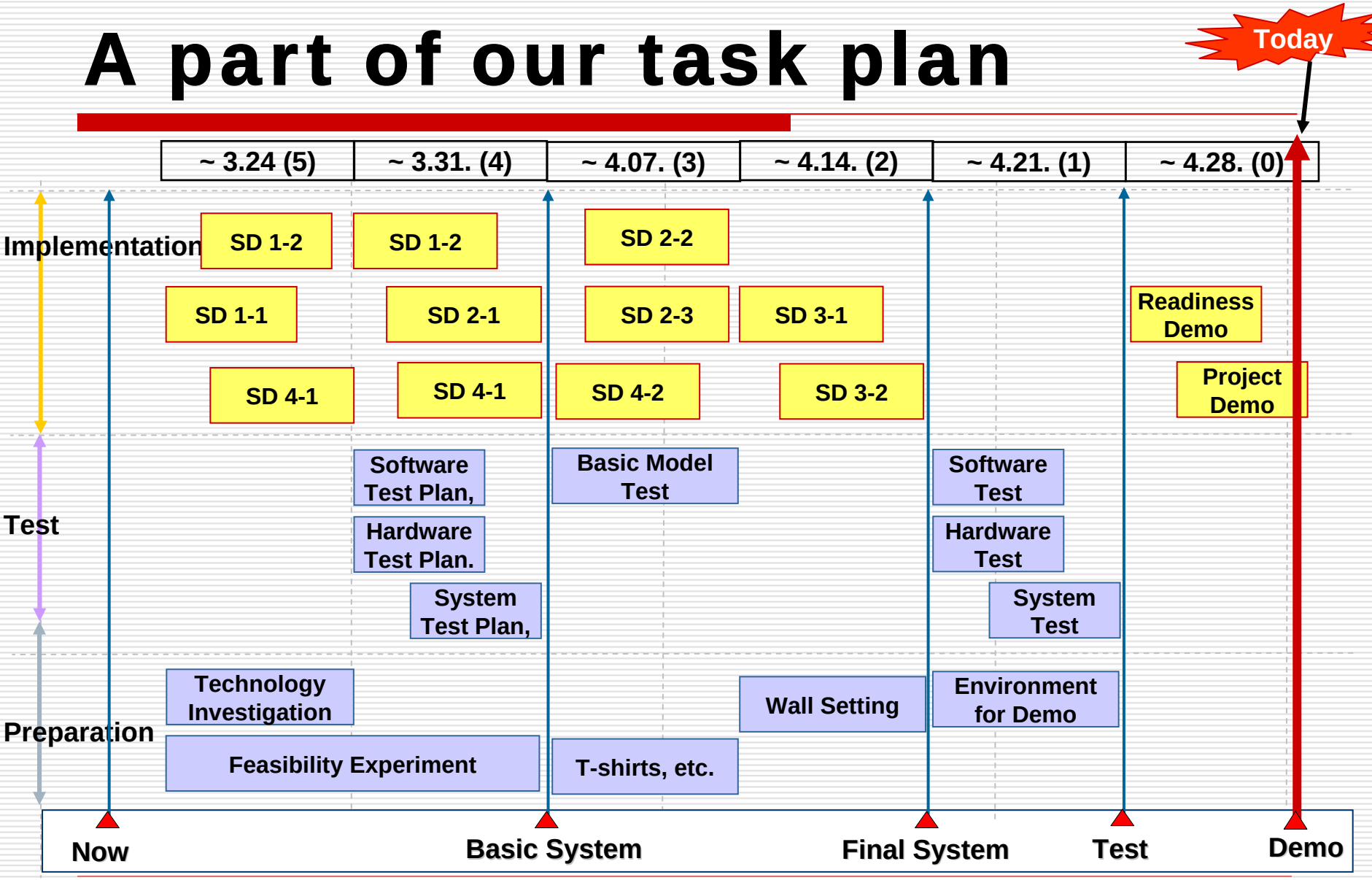
- Team homepage :
  - http://www.andrew.cmu.edu/org/littleredteam/index.html

Little Red Team

Our system life cycle

1. Identification of Mission and Need
2. Vague Notion of new System
3. Needs Statement with Measure of Effectiveness
4. System Requirements with Qualification Methods
5. Requirements, Specifications and Verification Methods
6. Design System, Software and Hardware Architectures
7. Development and Test
8. System Integration, Qualification and Validation
9. Usage and Maintenance (fixes and evolution)
10. Disposal (Replacement by new system)

A part of our task plan



System Requirements

- Reference.
  - System Requirement 01/26/2005
  - Our customer is Professor Sam Harbaugh
- Without a large change of requirements, All requirements are implemented and fulfilled

Mission, etc.

- Mission
  - a robot to monitor its surroundings, notice an invader and notify the information to a remote user.
- Need
  - a robot to behave the basic functions of surveillance
  - a robot for distance student to control and monitor
- MOE
  - Demonstrate the robot through internet
- Vague Notion of new System
  - a robot to check if there is a moving object
  - a robot to be controlled through internet

System Requirements (1/5)

- RQ1: The main controller shall be capable of using the internet for communication between a remote user and the robot - Demonstration.
  - RQ1.1: The main controller shall provide the capability for a remote user to initiate and start the robot activity.
  - RQ1.2: The experiment environment shall provide the capability for a remote user to view the robot's behavior via the internet
  - RQ1.3: a remote user may use MSN messenger or P2P cam software
  - RQ1.4: The surveillant robot shall notify the detection to a remote user through internet

System Requirements (2/5)

- RQ2: Robots shall autonomously wander for monitoring its surroundings – Demonstration.
  - RQ2.1: Robots shall detect walls by using touch sensors

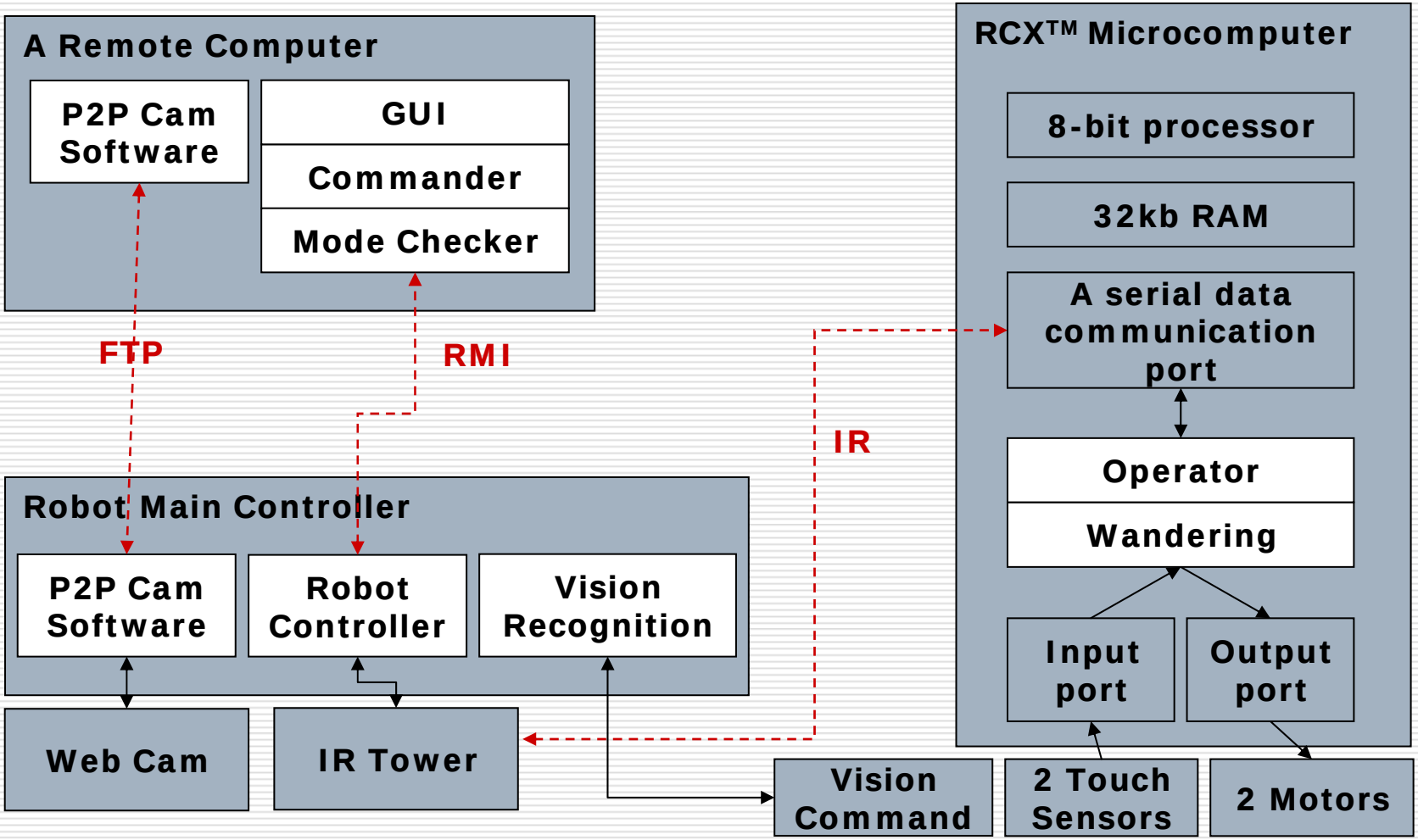
System Requirements (3/5)

- RQ3: Robots shall detect a moving object by using a camera in the monitored area – Demonstration.
  - RQ3.1: This system may have two robots: a surveillant robot, an invader robot
  - RQ3.2: The surveillant robot shall recognize whether a moving object is the invader robot or not by specific color
  - RQ3.3: The invader robot also may recognize whether a moving object is the surveillant robot or not
  - RQ3.4: The invader robot may run away to the exit when he is detected by the surveillant robot

System Requirements (5/5)

- RQ5: A development environment of a robot shall be java based environment - Demonstration

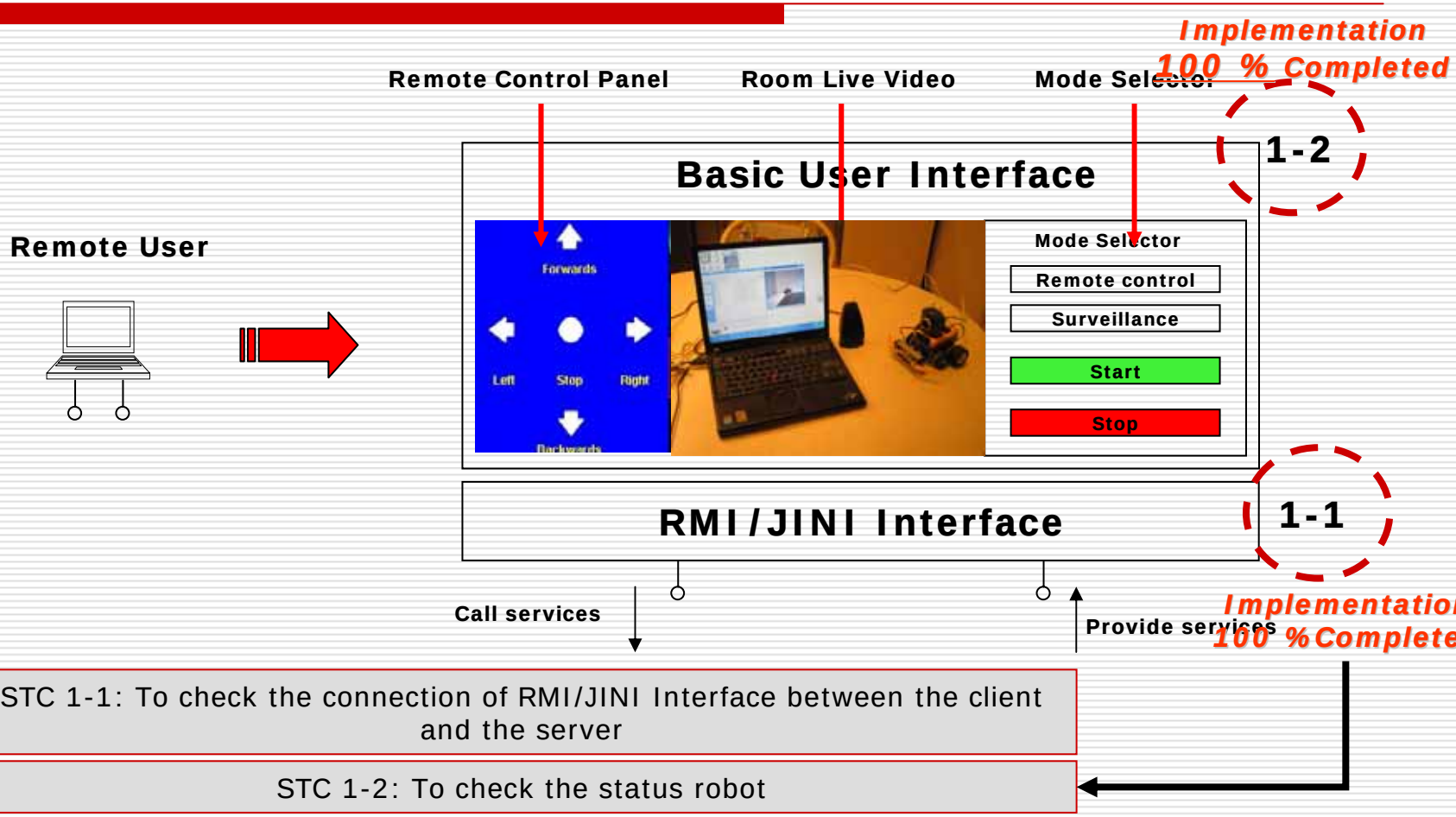
Functional Architecture



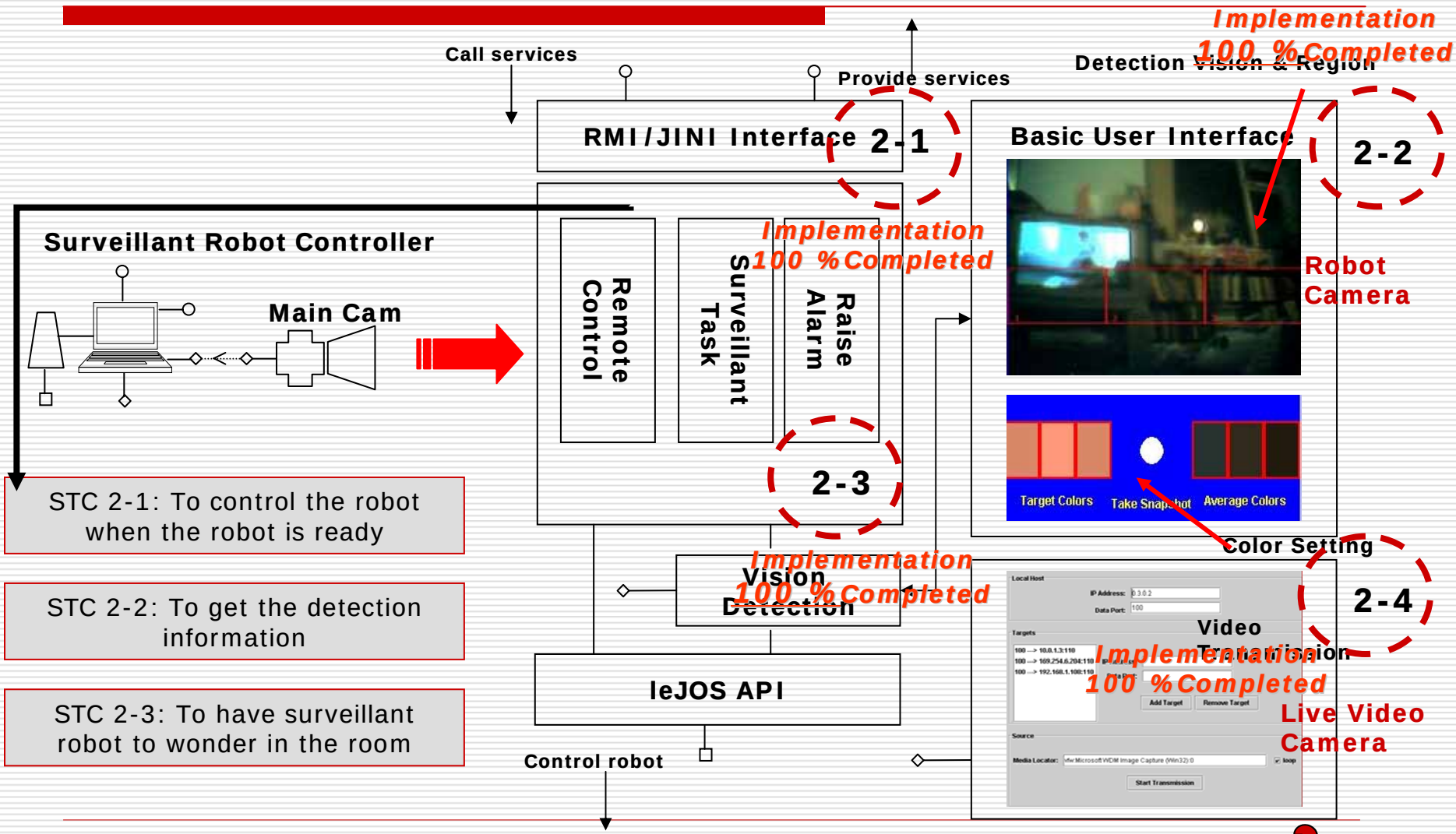
System Design

- Reference.
  - Status Report 04/18/2005

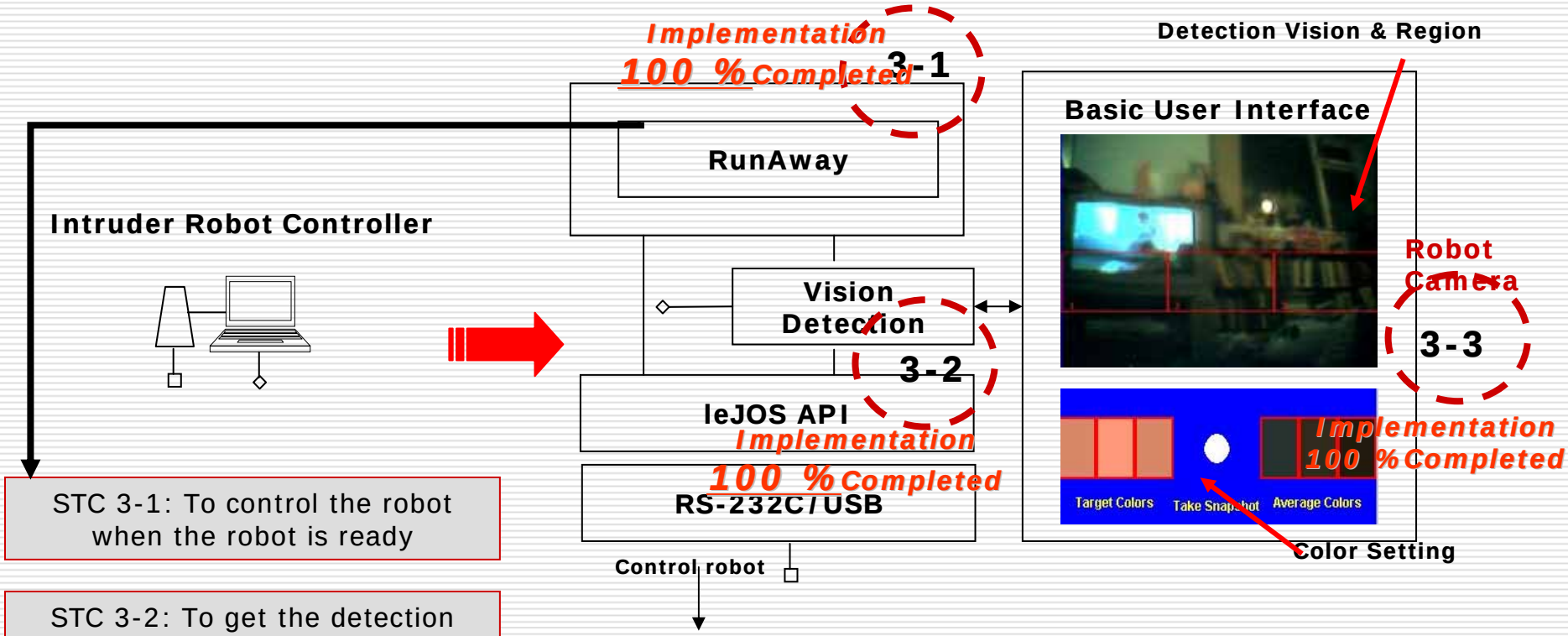
Software Design – SD#1



Software Design – SD#2



Software Design – SD#3



STC 3-1: To control the robot when the robot is ready

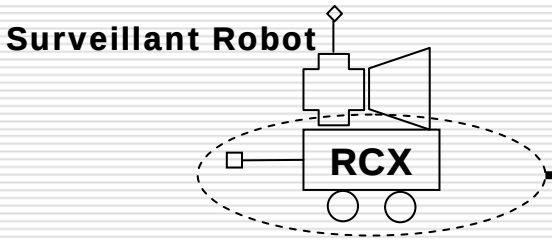
STC 3-2: To get the detection information

STC 3-3: To have surveillant robot to wonder in the room

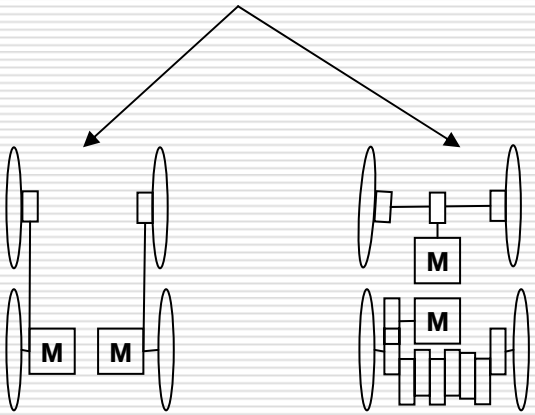
Software Design – SD#4

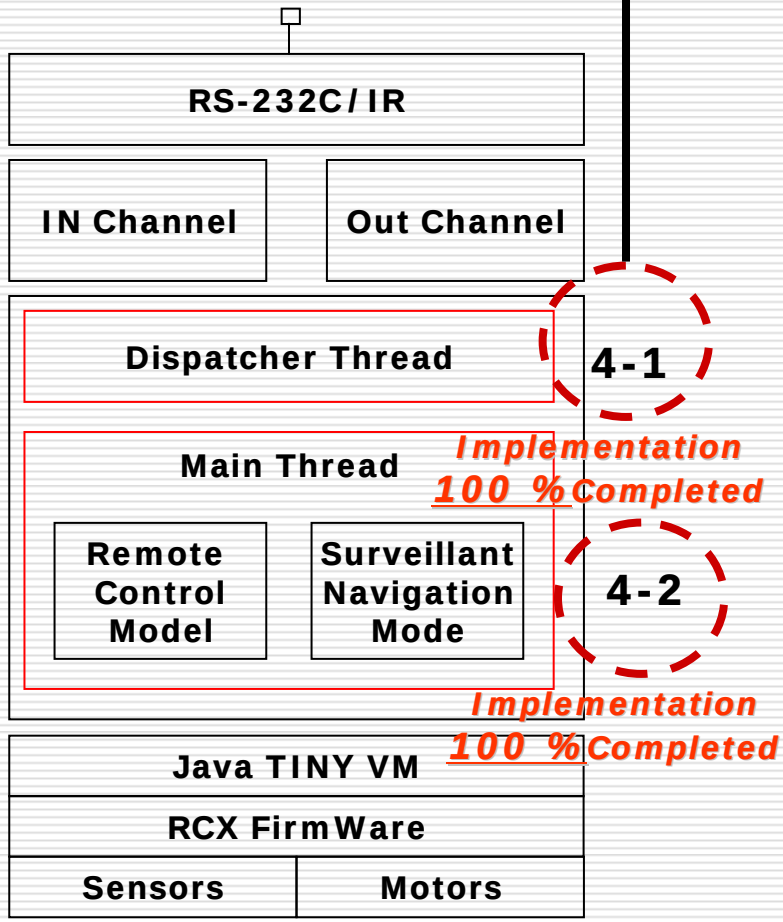
STC4-1: To check dispatcher thread

STC4-2: To check main thread



Two wheel drive mechanisms





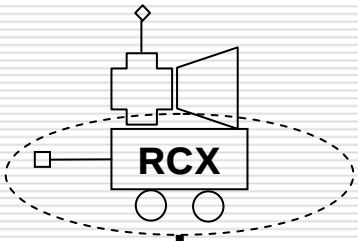
HTC1-1, HTC1-2 is testing

Software Design – SD#5

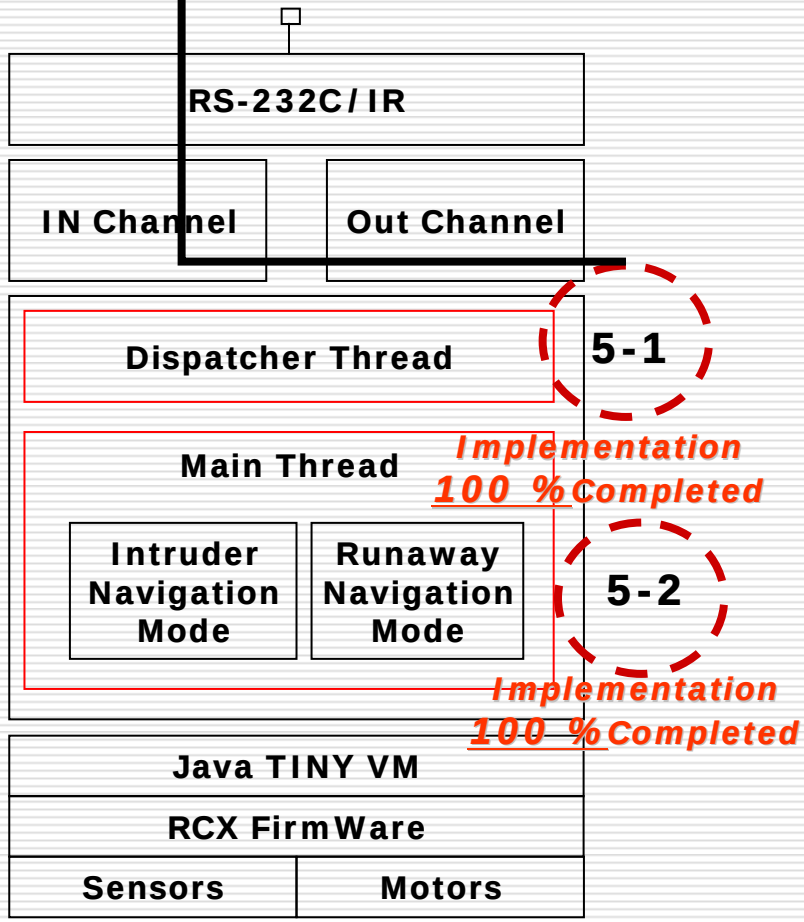
STC5-1: To check dispatcher thread

STC5-2: To check main thread

Intruder Robot



HTC2-1 is testing



Four important features

- How to navigate all rooms
  - Just use two touch sensors and one light sensors. Mindstroms only provided these sensors in their package. → This is our hardware constraint.
- How to enable remote user to control robot and to be notified
  - Use Internet network
  - Use Java RMI or JINI technology
- How to control a robot who is doing his work autonomously
  - Java Thread
  - Infrared Communication

Used H/W Technologies

- Lego Mindstorm :
  - A creative toy. It stimulus the power of imagination. Provides Vision API for color detection. It includes a microcomputer.
  - We just use two touch sensors to detect walls and one light sensor to navigate all rooms.
- Three cameras
  - Two cameras are used for detecting opposite. They are mounted to each robot.
  - Last camera is for providing god's side view for room.
- Three computers
  - The first is for remote user. The second is for surveillant. The last is for intruder
- Internet

Used S/W Technologies

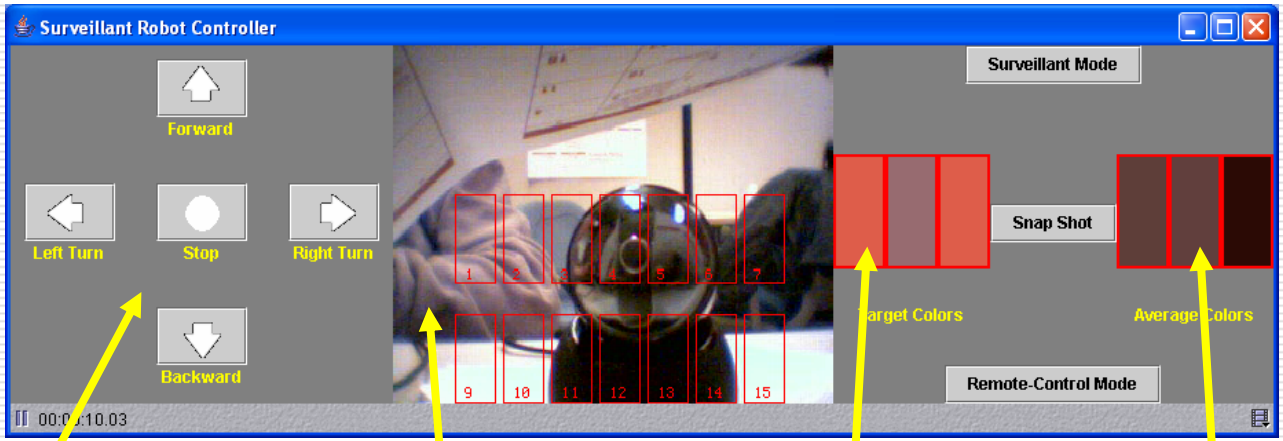
- lejOS : Java Tiny VM for lego mindstorm RCX
  - RCX is a microcomputer.
  - Has a role which is a small OS for RCX
  - Provides Vision API for color detection
- Java Thread
  - Actually, two threads are executed on runtime in the RCX program.
- JMF(Java Media Framework)
  - Provides video stream send and receive API via internet.
  - Vision API also use this API
- Java RMI (Remote Method Invocation) API
  - Remote user controller and surveillant controller use this API
- Development tools : Eclipse, lejOS Editor & Complier

Difficulties and constraints

- IR(Infra-Red) Tower
  - Originally, it is for downloading RCX program into RCX.
  - In our system, we use it as control channel of robots as well as program download
- Vision for recognition.
  - It's very sensitive and vulnerable to lighting and the surroundings.
  - This problem is still an issue which is not easily to be solved to computer vision research areas.
- Toy – few sensor
- Tethered Camera vision

S/W & H/W introduction

Surveillant Robot Controller



Robot control Panel

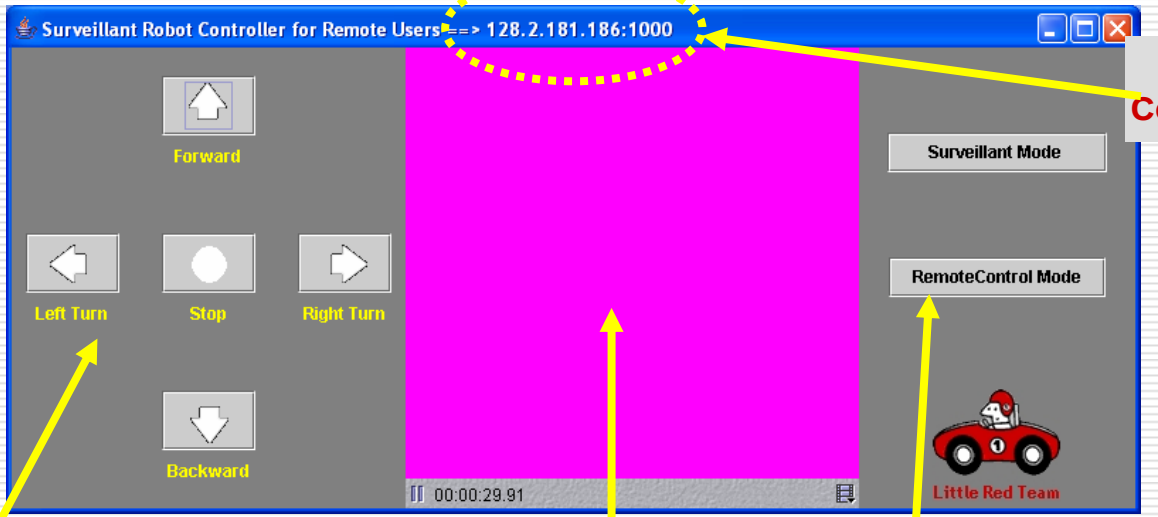
Surveillant Robot Side view

Targets colors for Detecting intruder

Average Colors Value Of Current View

- This program is for local control of surveillant robot.
- It also provides RMI interface for remote users

Surveillant Robot Controller for Remote Users



Surveillant Main Controller IP address

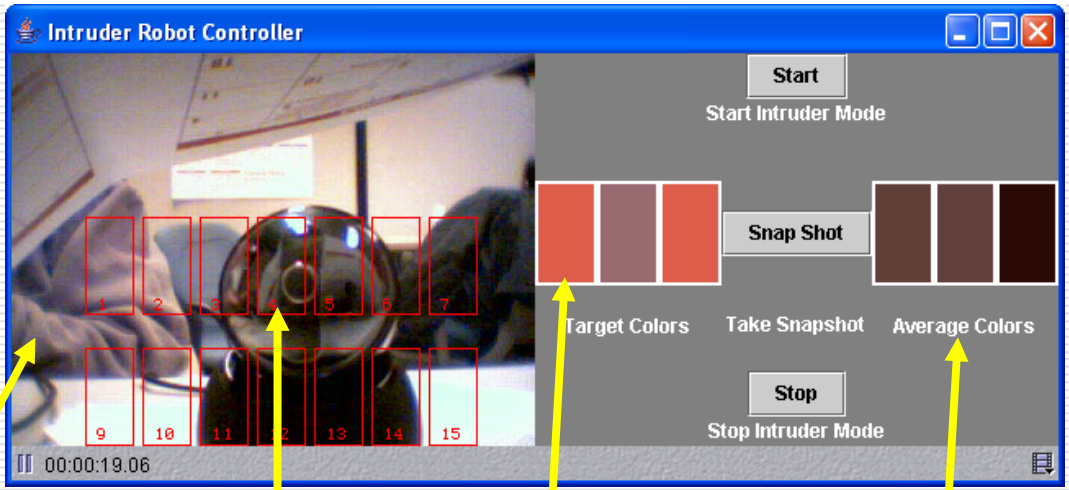
Robot control Panel

Room Live Video from Surveillant Robot Side view

Model switching Panel

- This program is for remote control of surveillant robot.
- It also provides RMI interface for main controller

Intruder Robot Controller



Surveillant Robot Side view

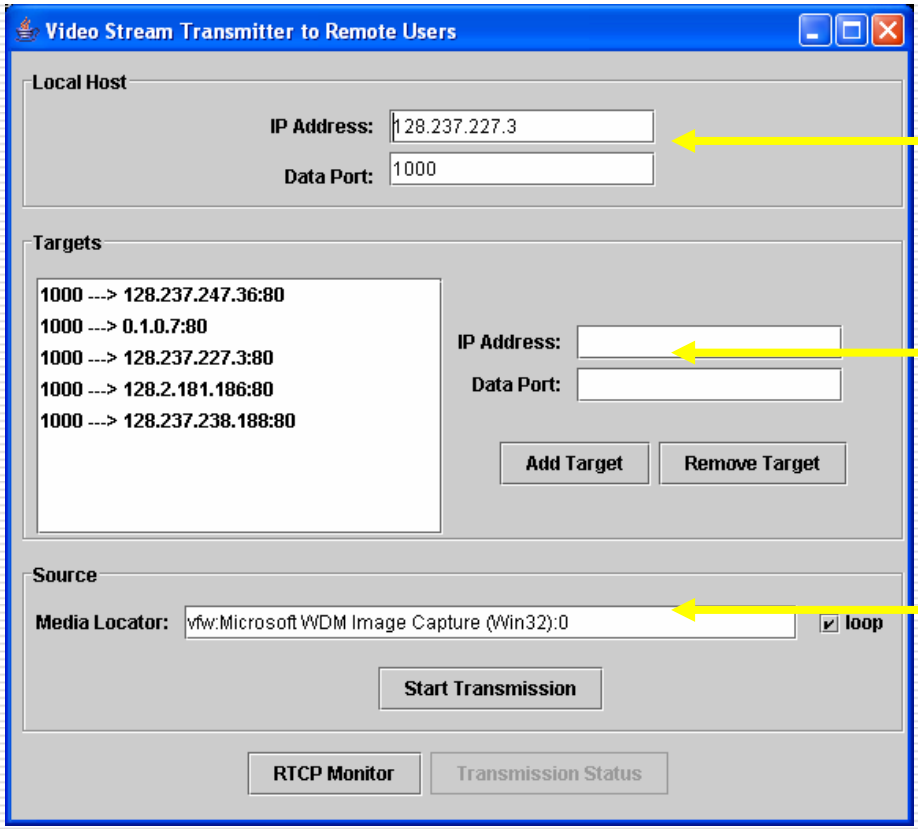
Regions for color detection

Targets colors for Detecting surveillant

Robot control Panel

- This program is for local control of Intruder robot.

Video Stream Transmitter for God eye's view

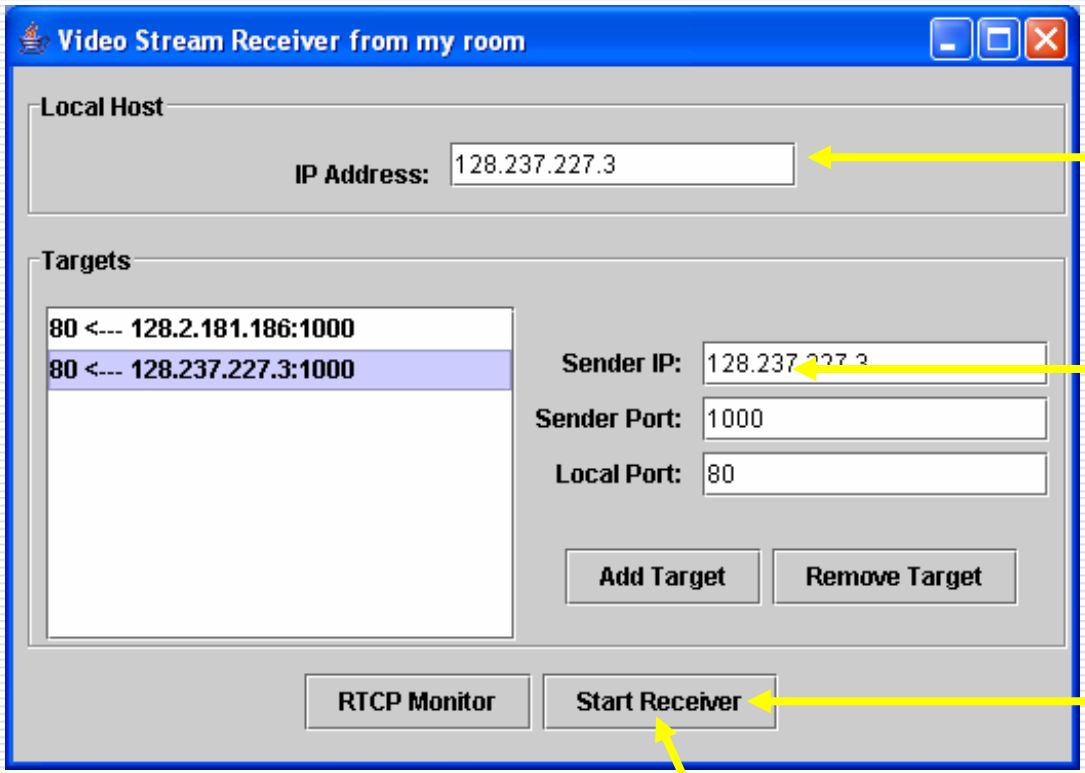


Local IP Address

Target IP Address

Camera source

Video Stream Receiver for God eye's view



Local IP Address

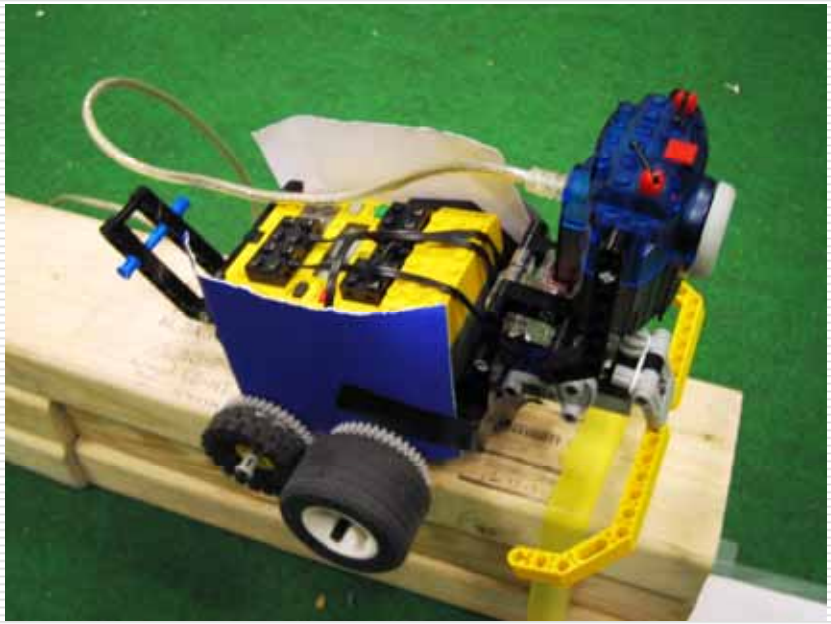
Sender IP Address

Camera source

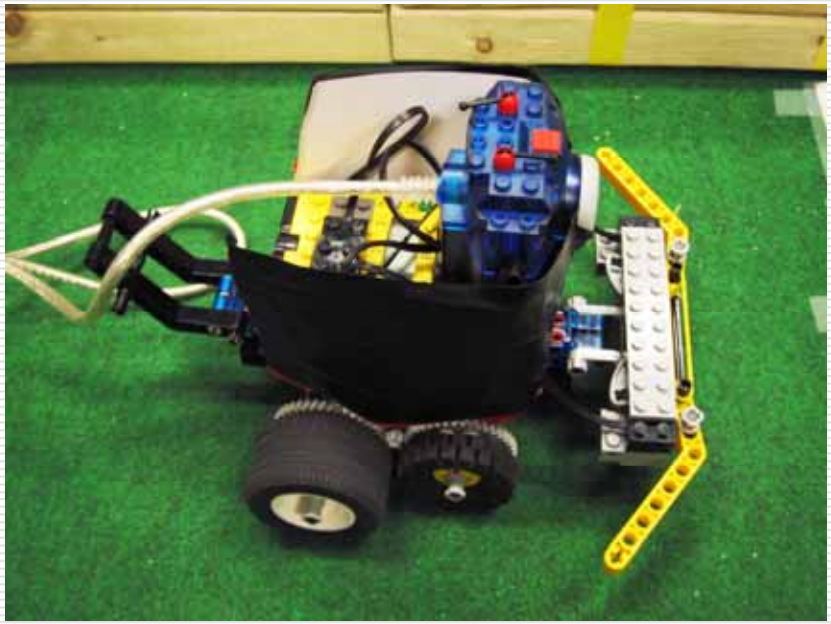
After this button clicked, remote users can Control surveillant robot

Robots

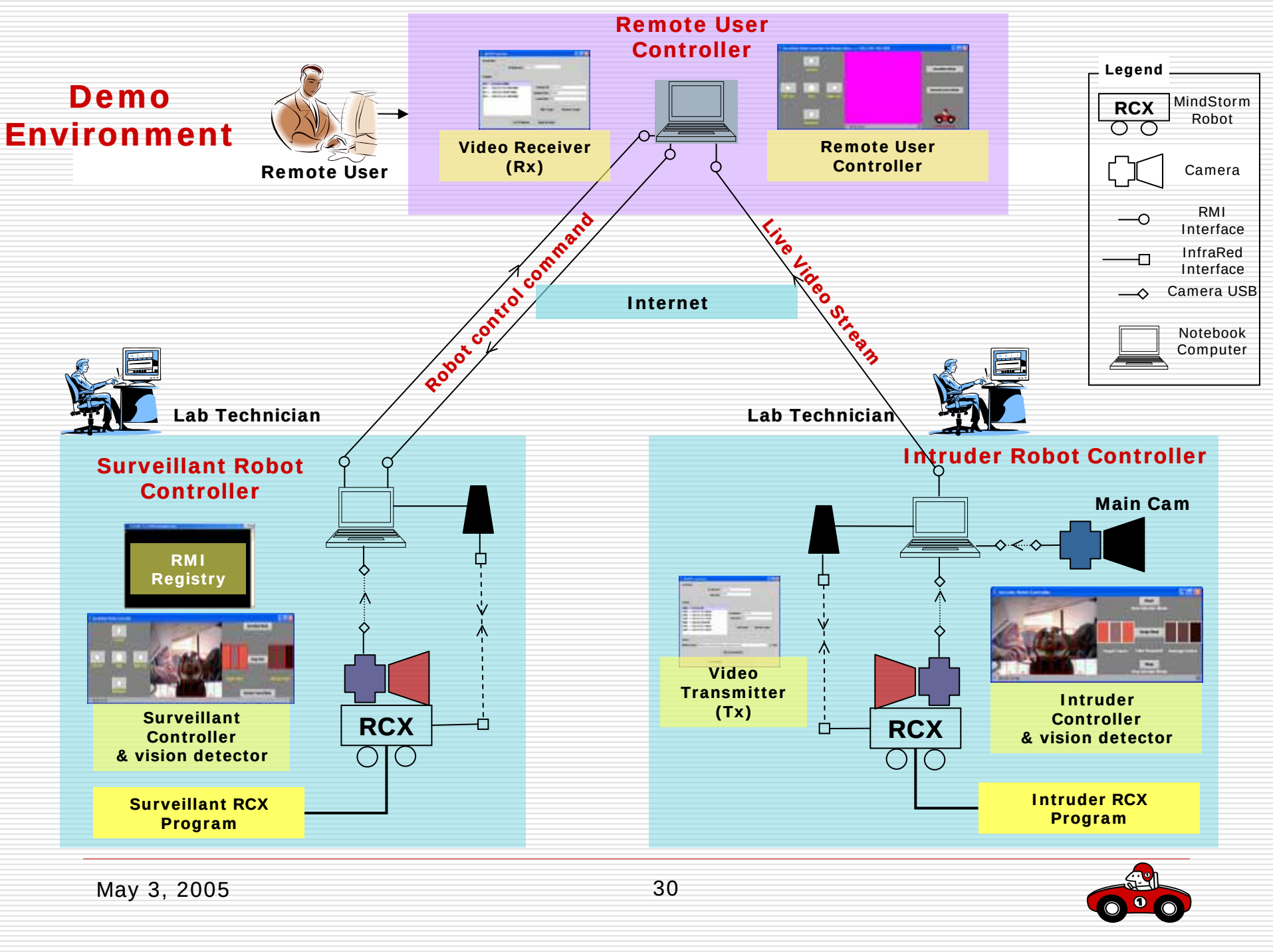
Surveillant Robot



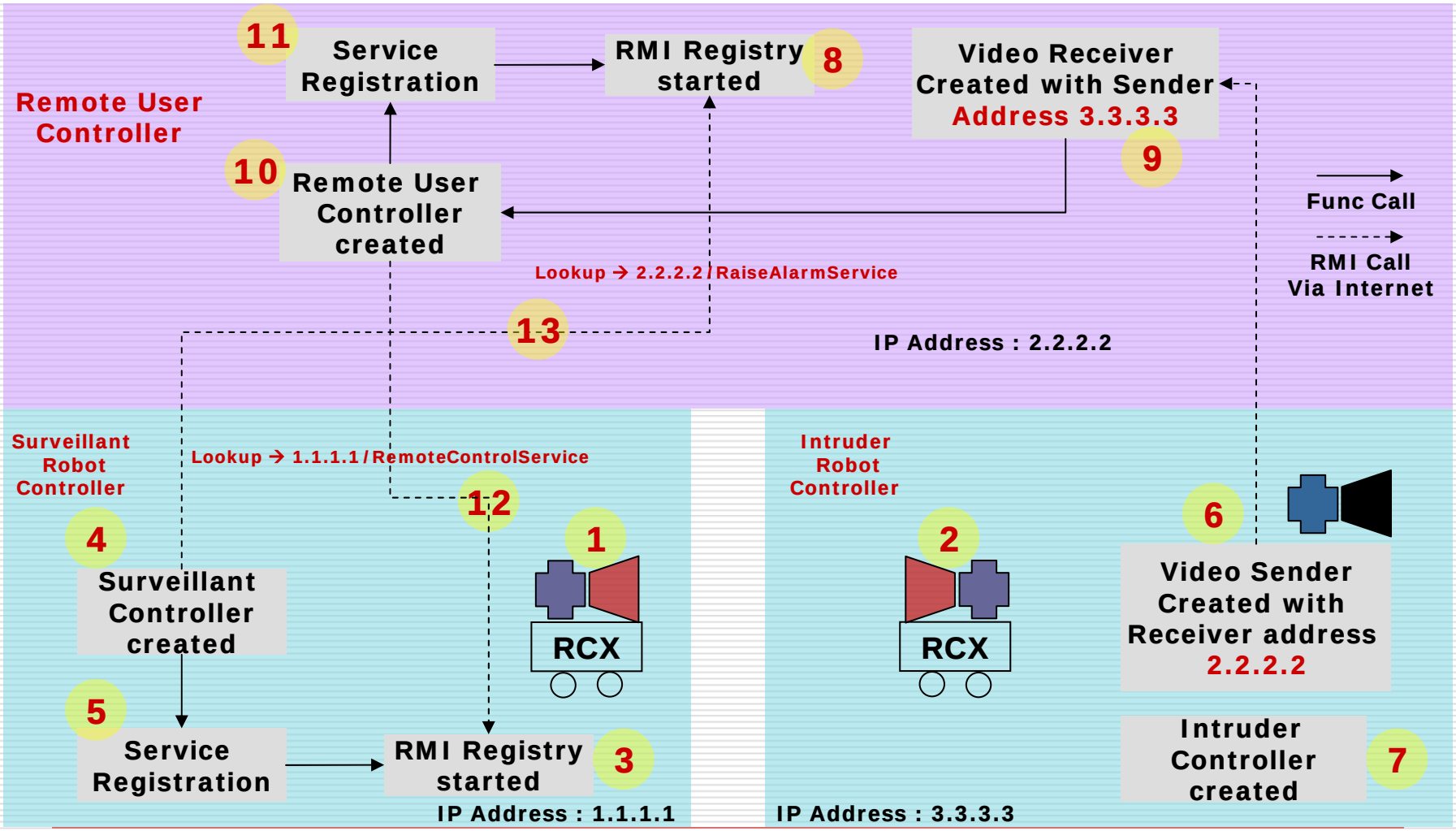
Intruder Robot



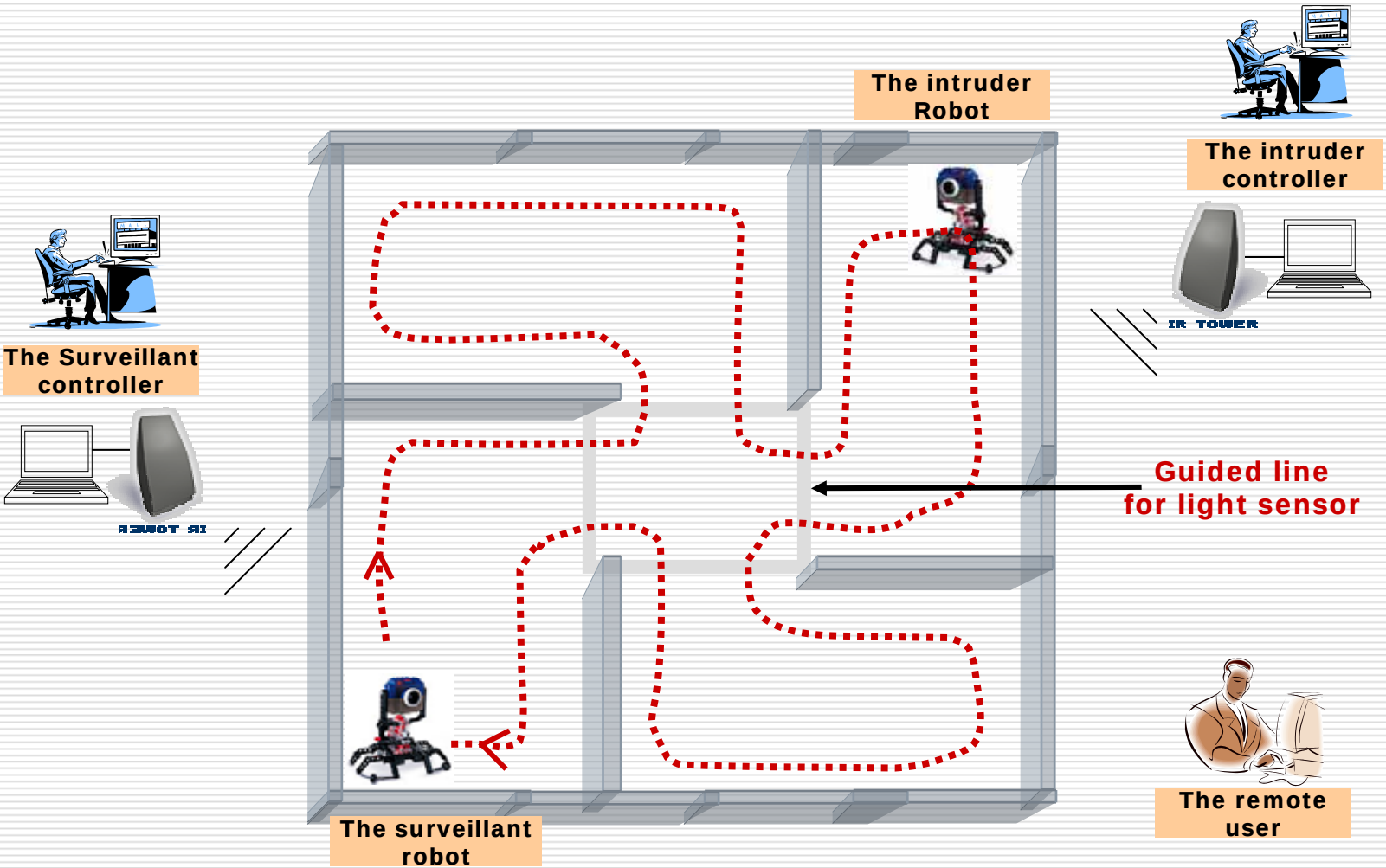
Demo Environment



Initialization procedure



Actual Layout of demo room



Demonstration Scenario

1. show how to control the robot remotely by remote user – Remote control mode
2. show how to navigate all rooms
3. show that the surveillant robot perform actual surveillant mission in the room. – Surveillant Model
   - ✓ When the surveillant robot detects opposite intruder robot, he stop and notify the detection to remote user. And then, Security alarm sound will be raised in the remote user computer.
   - ✓ On the other hand, when the intruder robot detects surveillant robot, he is surprised and begin to spin.

Future Consideration

- Future enhancement points
  - If we have rotation sensors, we can measure nearly exact degree of wheel moving. So, we can sure that robot's exact turn and moving straight properties.
  - If real battery station is made, robots can perform real surveillant tasks since their batteries can be endlessly recharged by the battery station.
  - IR Tower's sensitivity is very low. This problem is not solved. This is hardware constraint. → Alternatives are Bluetooth and RF.
  - Tethered Camera is very ineffective to demonstrate our robot system. Also, it is impossible to apply to real life→ Wireless camera is a good candidate.

Lessons learned

- Reflection
  - We made efforts to apply various disciplines of system engineering to our robot project. However, many issues are not immersed into our project than we expected.
  - System engineering → People, S/W, and H/W → Our little red team showed enough team work and harmonization. → I appreciate my team member.
- Design decision significantly influences on the cost of purchasing the robot system
- Trade analysis for deciding a robot system shows the rationale to decide a robot
- While system implementation are completed, In practical demonstration or use, if the system is not properly operated, our efforts are meaningless. So, integration and tests should be executed meticulously and we realized that we should do our best until final release.