CG4002: Computer Engineering Capstone Project

Visualizer and Game Engine

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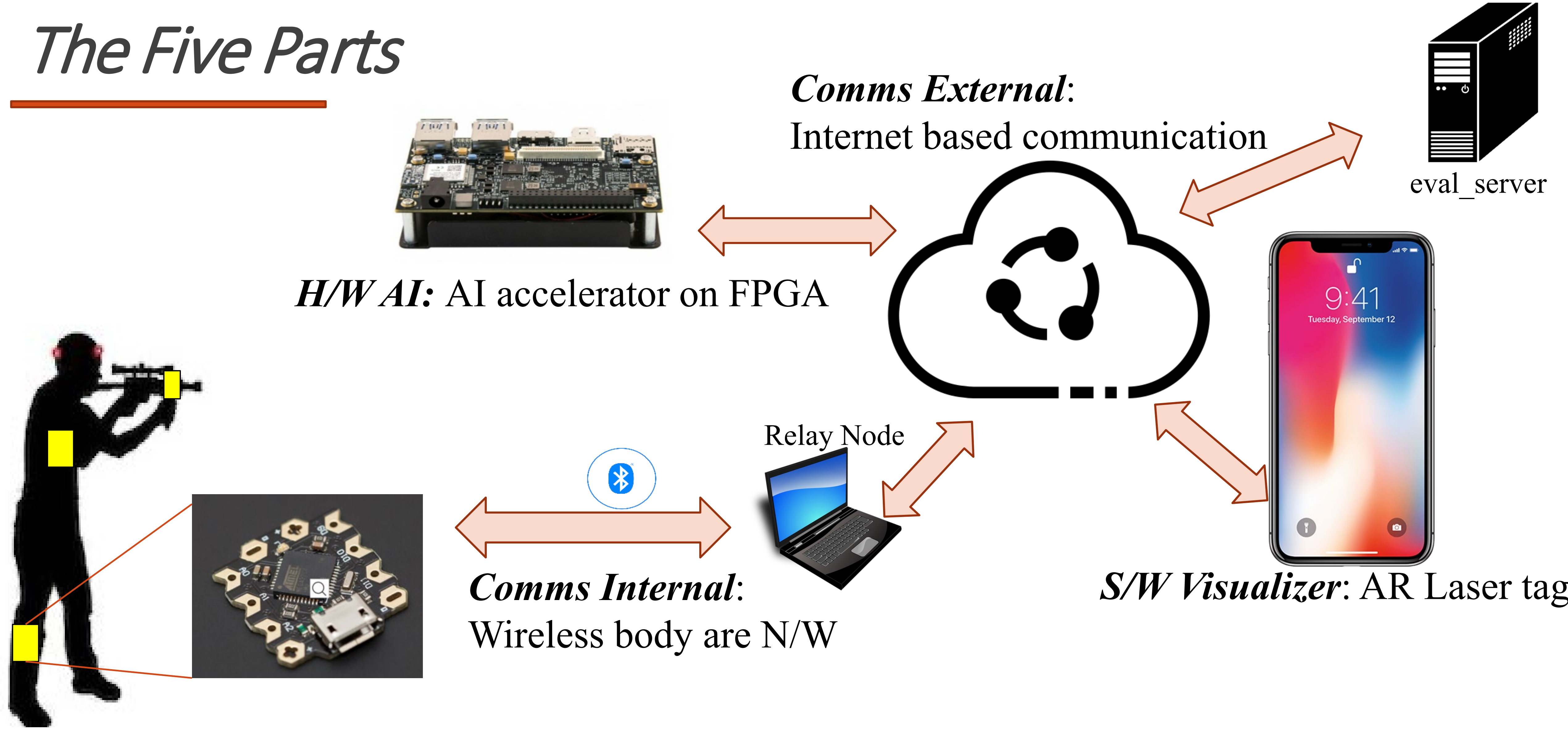
Slides adopted from
Prof. Peh Li Shiuan

The Five Parts



***Comms External*:**
Internet based communication

eval_server

H/W AI: AI accelerator on FPGA

Relay Node

***Comms Internal*:**
Wireless body are N/W

***S/W Visualizer*:** AR Laser tag

***H/W sensors*:** Laser tag gun, target, sensors

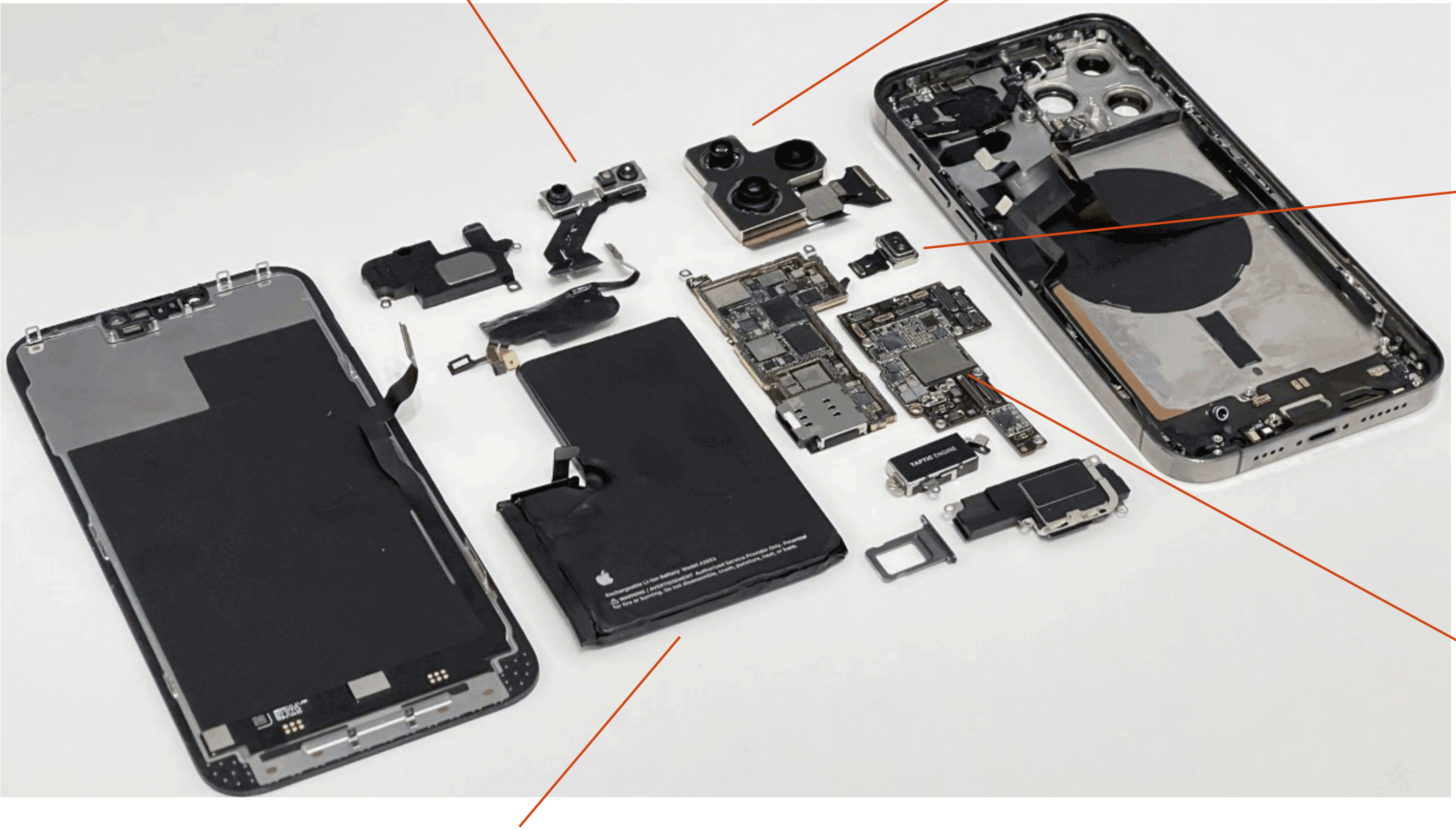
CG4002 Project: Laser tag

What's in a modern (smart) phone?

iPhone 13 Pro Max

Other Sensors:

- barometer
- three-axis gyro
- accelerometer
- proximity sensor
- ambient light sensor



TrueDepth Camera System

Telephoto lens, Wide lens, Ultra-wide lens

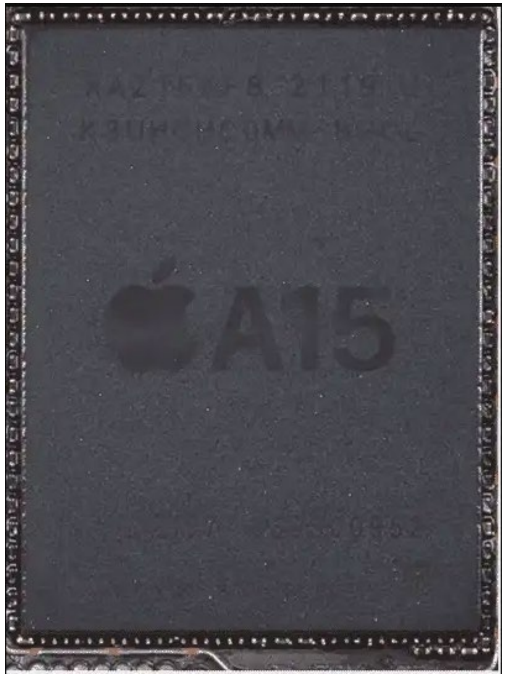
LiDAR

Apple A15 Bionic

4352 mAH battery

Source: https://unitedlex.com/insights/apple-iphone-13-pro-max-teardown-report/

Phone Processor: A15 Bionic



64-bit six-core ARMv8

- ◦ 2 high performance Avalanche cores
- ◦ 4 energy efficient Blizzard cores

15 billion transistors

Dedicated 16-core Neural Engine hardware

- ◦ 15.8 trillion operations per second

Image processor

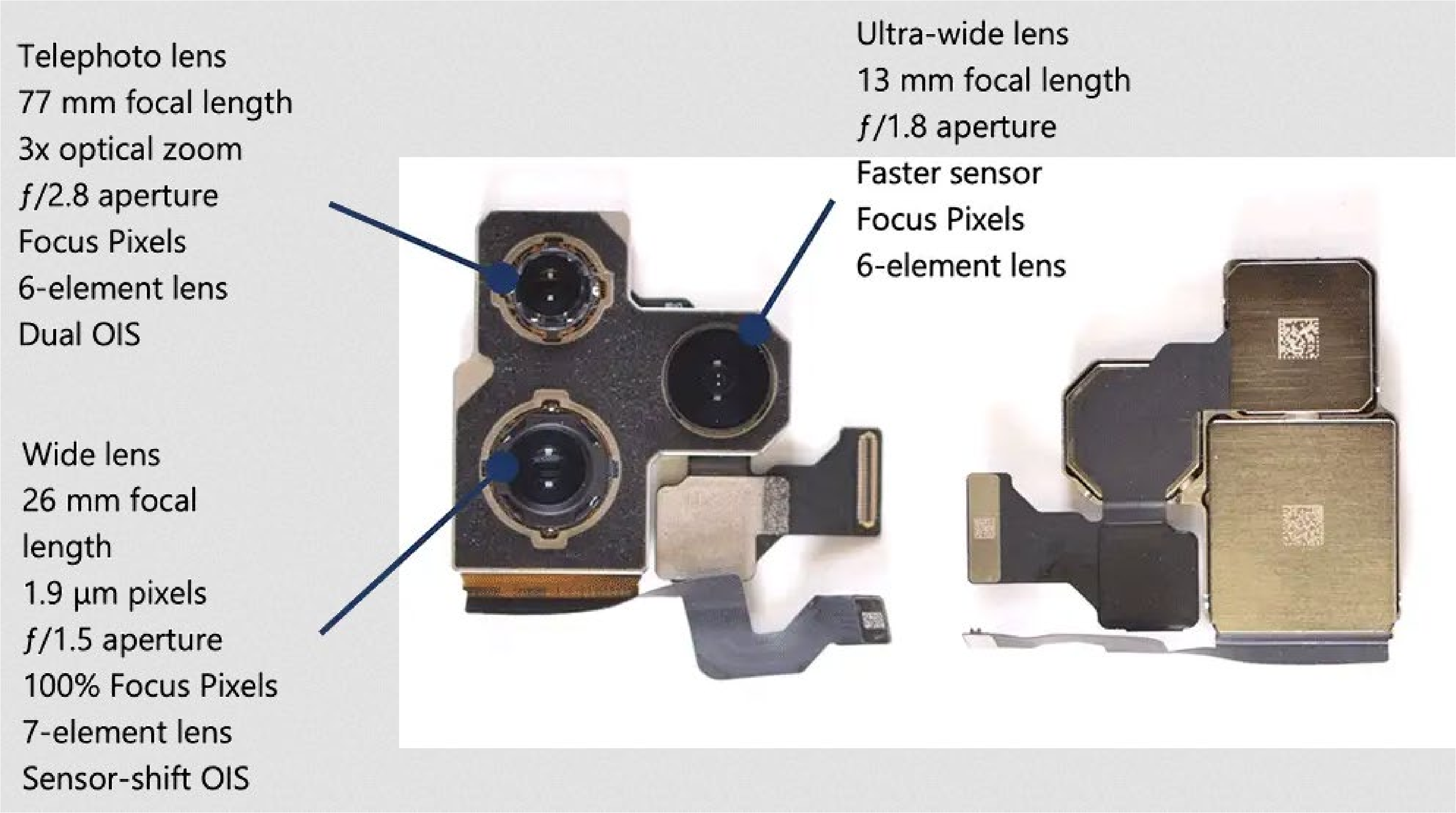
Five-core GPU

6GB RAM

Compare to other CPUs:

- Core i7 (2008): 731 million transistors
- Xeon Ivy Bridge (2014): 4 billion transistors
- Xbox One X (2017): 7 billion transistors

Cameras



Telephoto lens
77 mm focal length
3x optical zoom
ƒ/2.8 aperture
Focus Pixels
6-element lens
Dual OIS

Ultra-wide lens
13 mm focal length
ƒ/1.8 aperture
Faster sensor
Focus Pixels
6-element lens

Wide lens
26 mm focal length
1.9 µm pixels
ƒ/1.5 aperture
100% Focus Pixels
7-element lens
Sensor-shift OIS

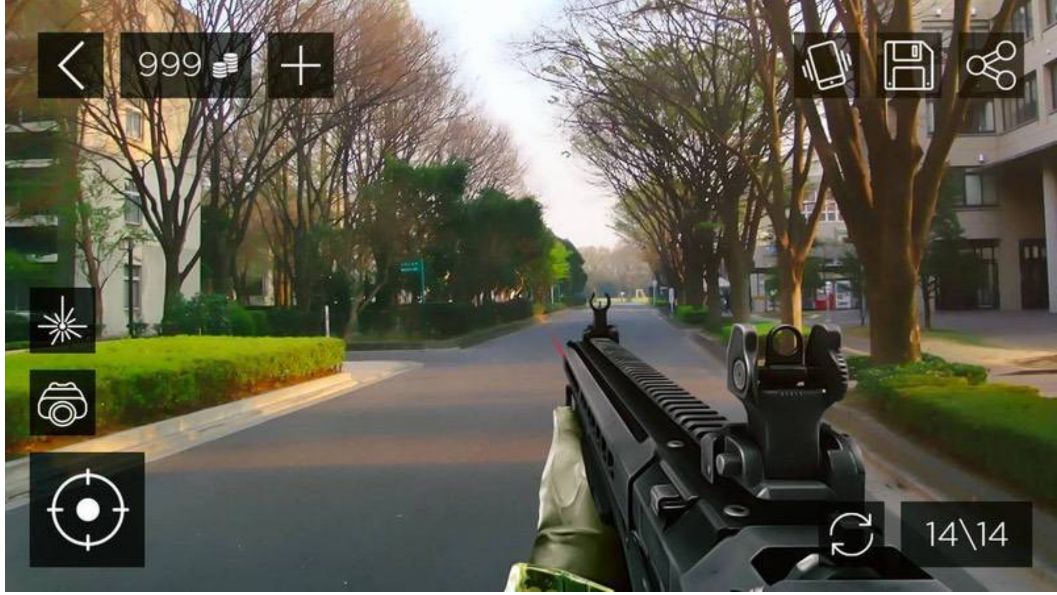
LiDAR System

- Light detection and ranging
- Emits pulsed light waves
  - Pulses bounce off objects and return to sensor
- Creates 3D map of environment
  - Point cloud
- Depth map -> helps AR apps

Software Visualizer

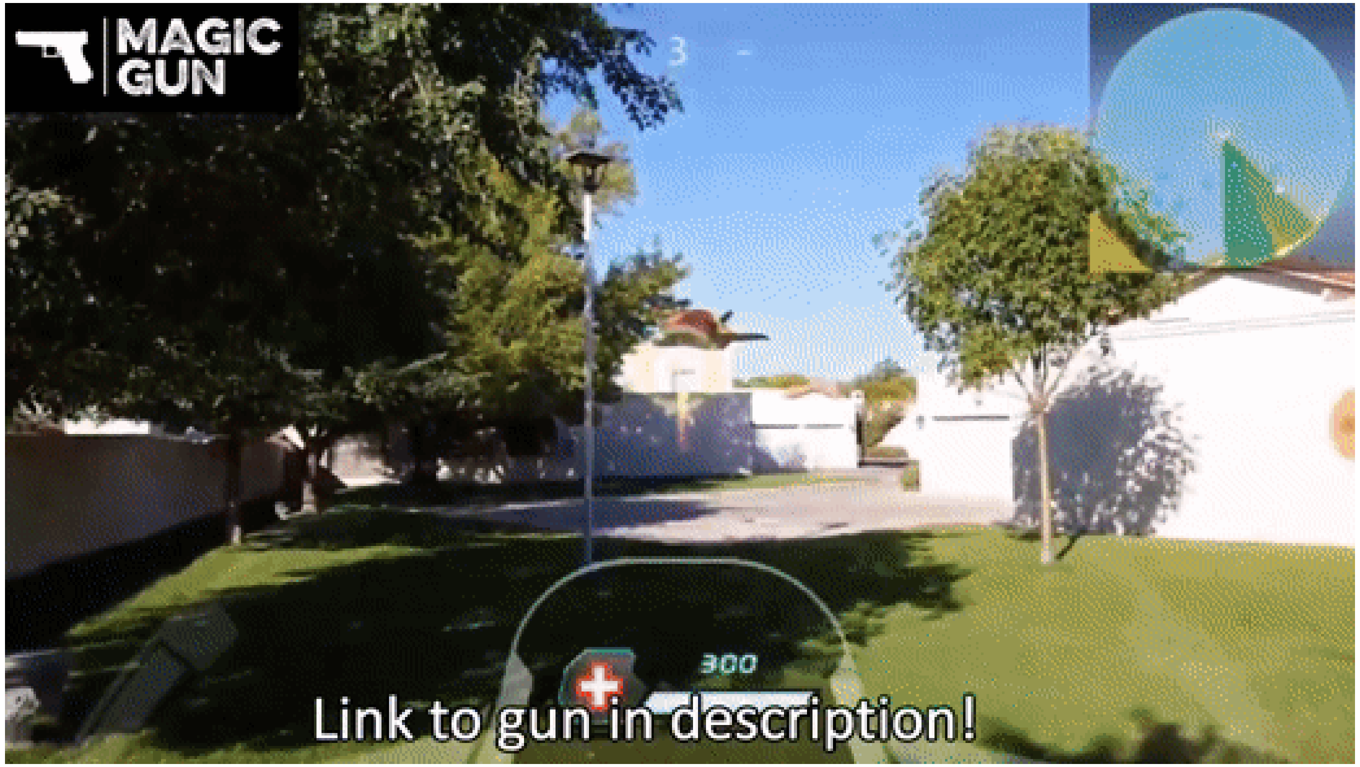
Software Visualizer

- Player’s window to the world
  - Phone as camera + display



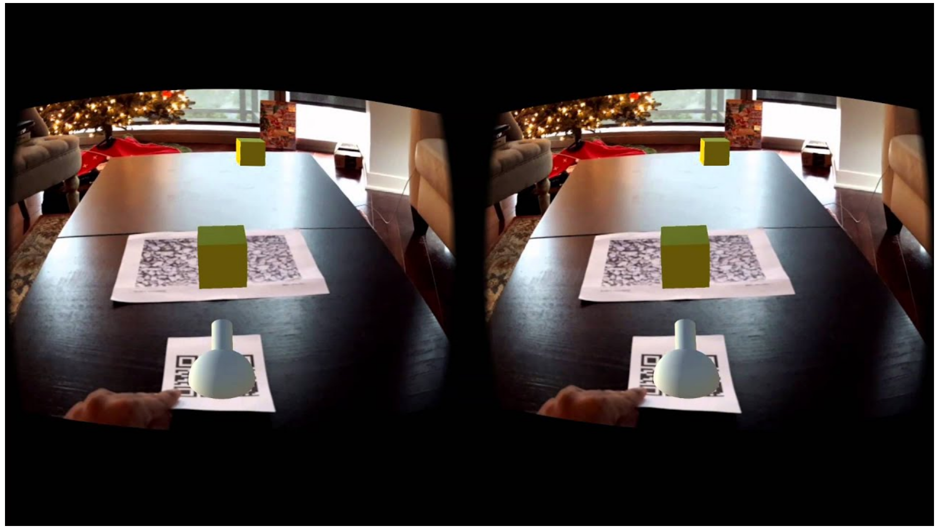
- What kind of information to show on the visualizer?
  - Game play: HP, ammo, etc.
  - The other player
  - Detected action
  - Effects of actions
- Advice: Avoid clutter
  - Debug mode is not the default mode

Software Visualizer



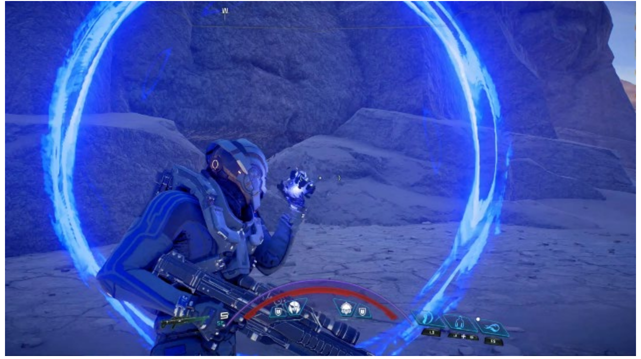
Where to place the phone visualizer?

- mount on gun
- AR headset



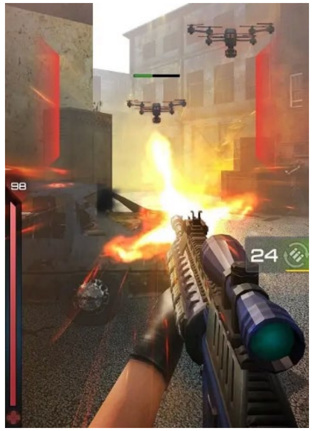
Effects of actions

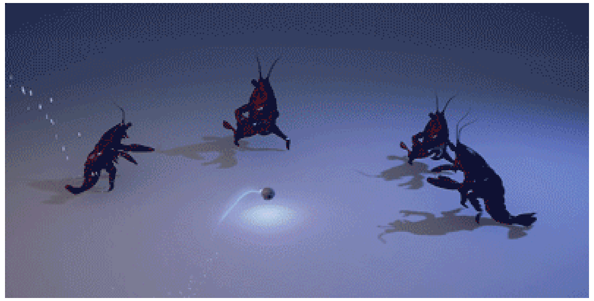
- Reload
  - Update info



- Shield
  - Nullify other players’ attacks, graphics

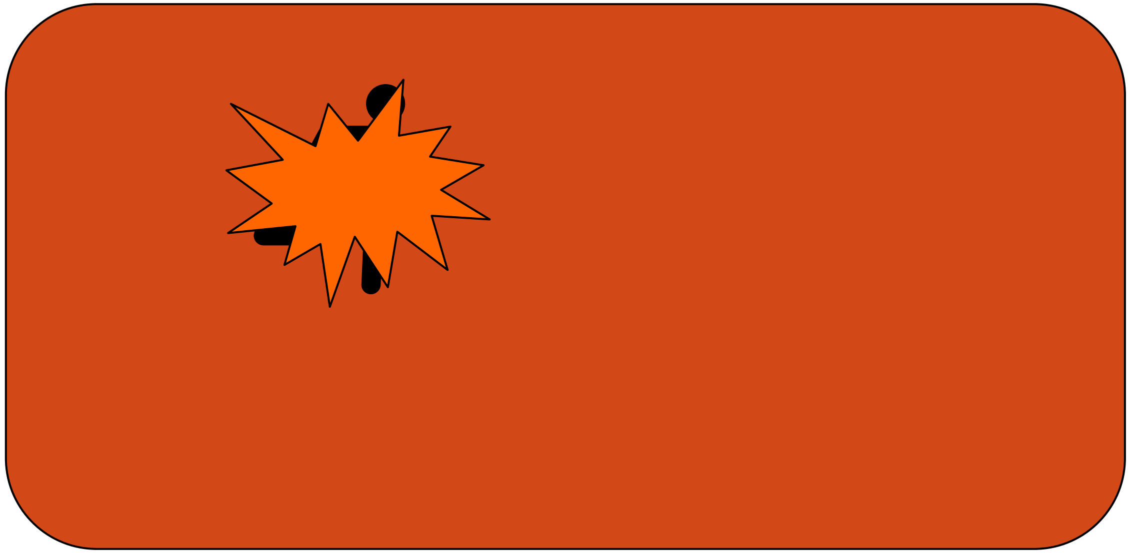
- Shoot
  - Graphics overlaid on other player



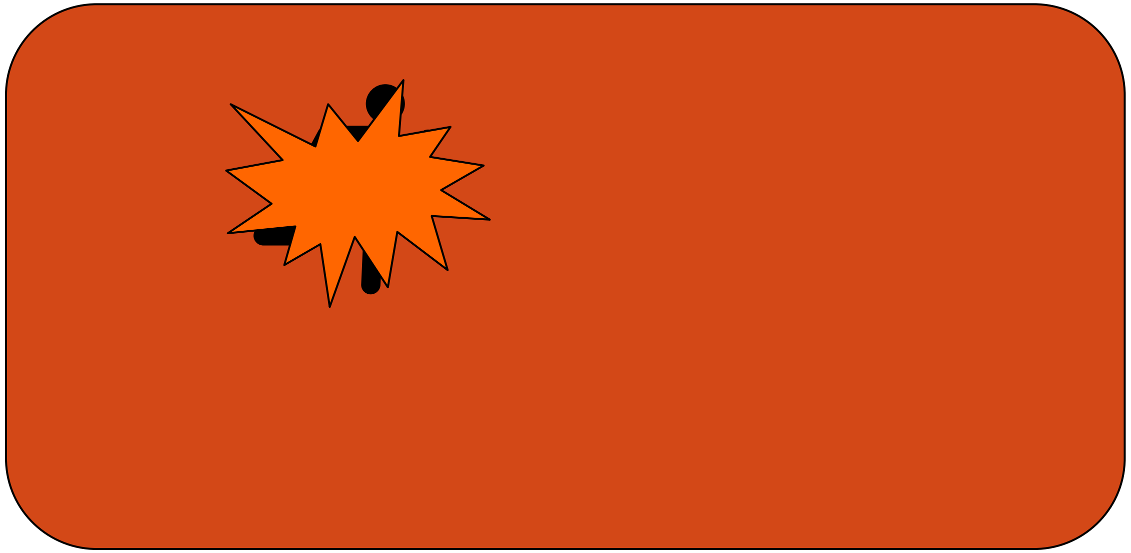


- Grenade
  - Graphics overlaid on environment and player

Example: Grenade – AR effects



Example: Grenade – AR effects



- Need to track player’s position in phone camera
- AR: camera, graphics

AR Basics: Motion Tracking

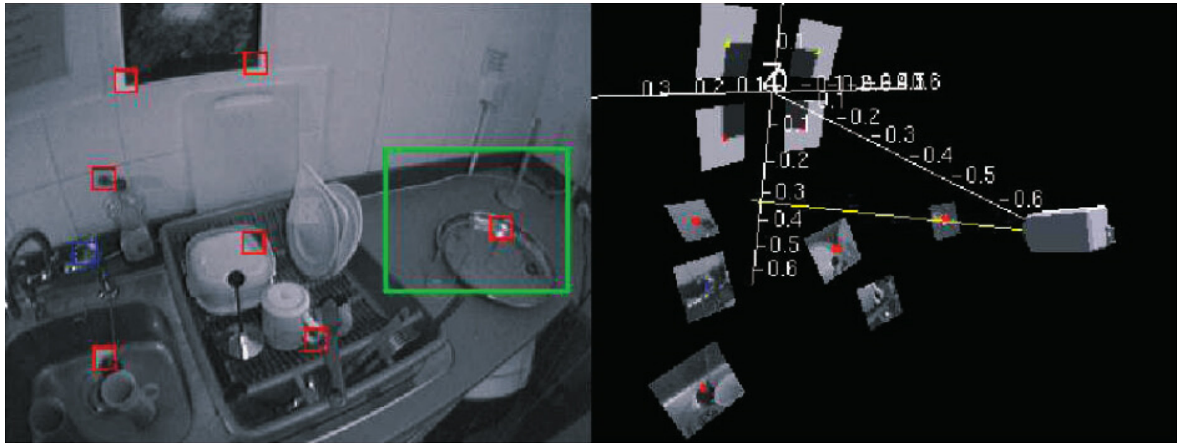
SLAM (Simultaneous localization and mapping)

Goals:

- Tracked feature points
- Their relation in space
- Inferred camera/device position

Uses sensor data from:

- Camera
- Accelerometer, Gyroscope
- GPS, light sensor, depth sensor



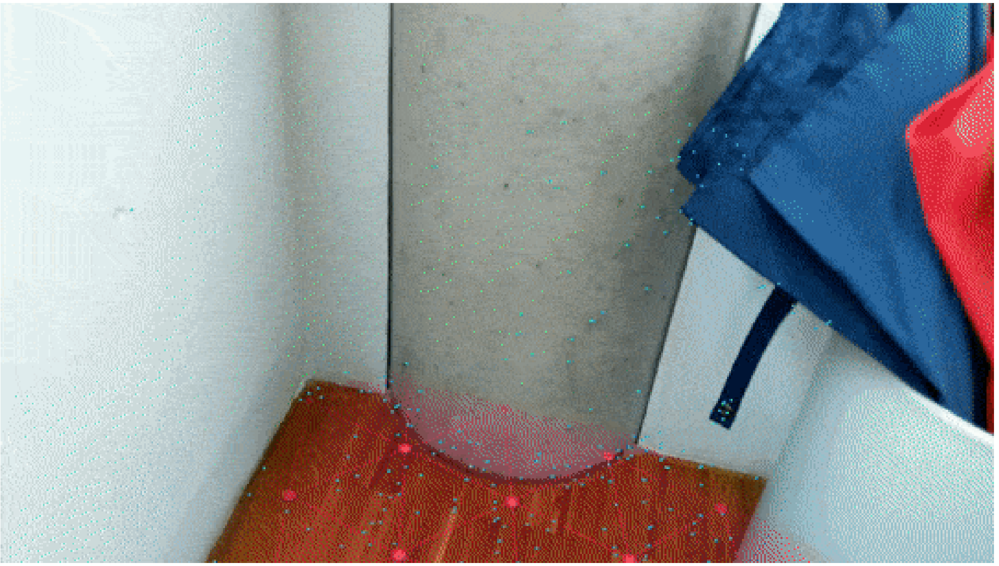
Source: MonoSLAM: Real-time single camera SLAM. Davison et al.

AR Basics: Anchoring Virtual Objects

Anchoring: ensure the object stays at the location where you put it

Where to anchor?

- Environment
- Visual marker (e.g., QR code)
- Person



How does it work?

- Detect feature points
- Feature points need to be reliable

Source: https://www.andreasjakl.com/basics-of-ar-anchors-keypoints-feature-detection/

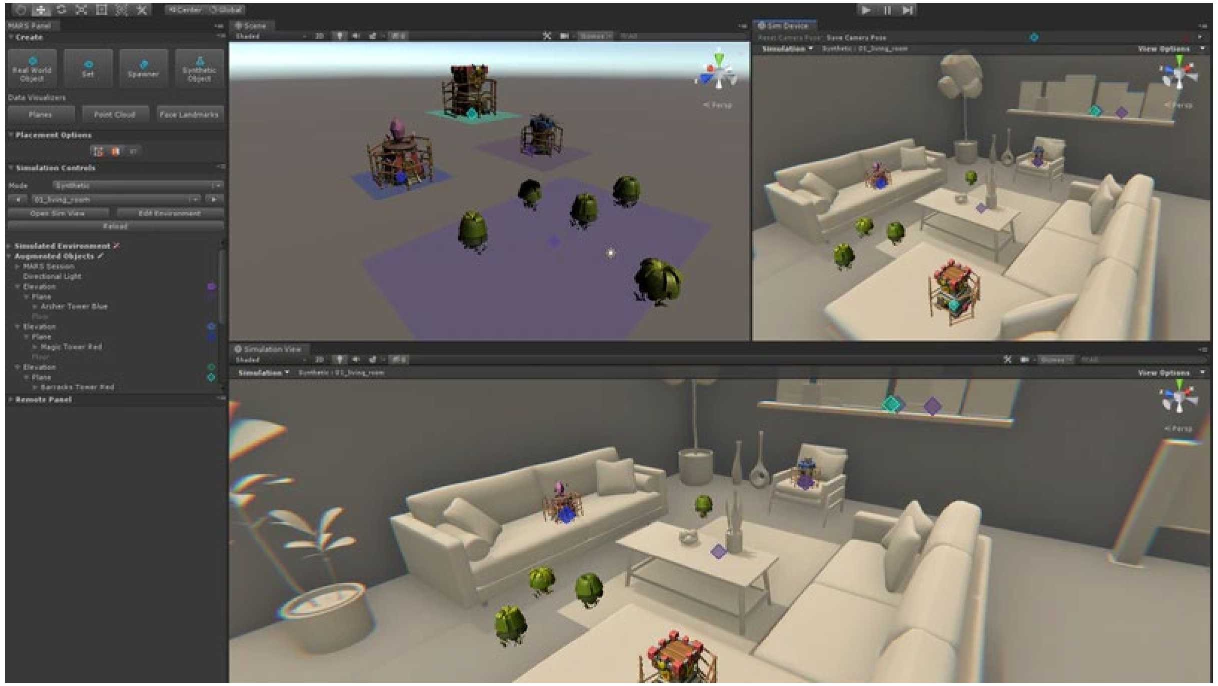
Programming and Development Framework

Unity: Game Engine

Unity

Use cases

- Able to develop AR applications
- Develop apps for multiple platforms
  - Android
  - iOS



AR Framework

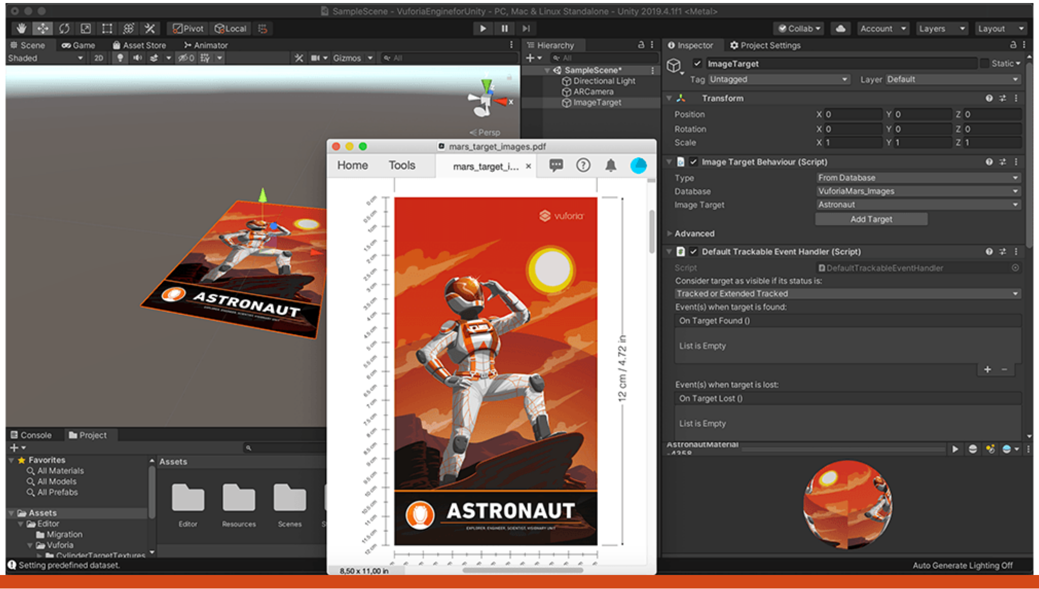
- Unity Frameworks
  - ***Unity AR Foundation***
  - ***Vuforia***

- Implements most of the low-level tracking, anchoring, detection algorithms

- Cross-platform
  - Android: ARCore
  - iOS: ARKit

AR Foundation

vuforia® engine™



SampleScene - VuforiaEngineforUnity - PC, Mac & Linux Standalone - Unity 2019.4.1f1 <Metal>

ImageTarget

Tag: Untagged
Layer: Default

Transform

	X	Y	Z
Position	0	0	0
Rotation	0	0	0
Scale	1	1	1

Image Target Behaviour (Script)

Type: From Database
Database: VuforiaMars_Images
Image Target: Astronaut

Default Trackable Event Handler (Script)

Script: DefaultTrackableEventHandler
Consider target as visible if its status is:
Tracked or Extended Tracked
Event(s) when target is found:
On Target Found ()
List is Empty
Event(s) when target is lost:
On Target Lost ()
List is Empty

Setting predefined dataset.

Game Engine

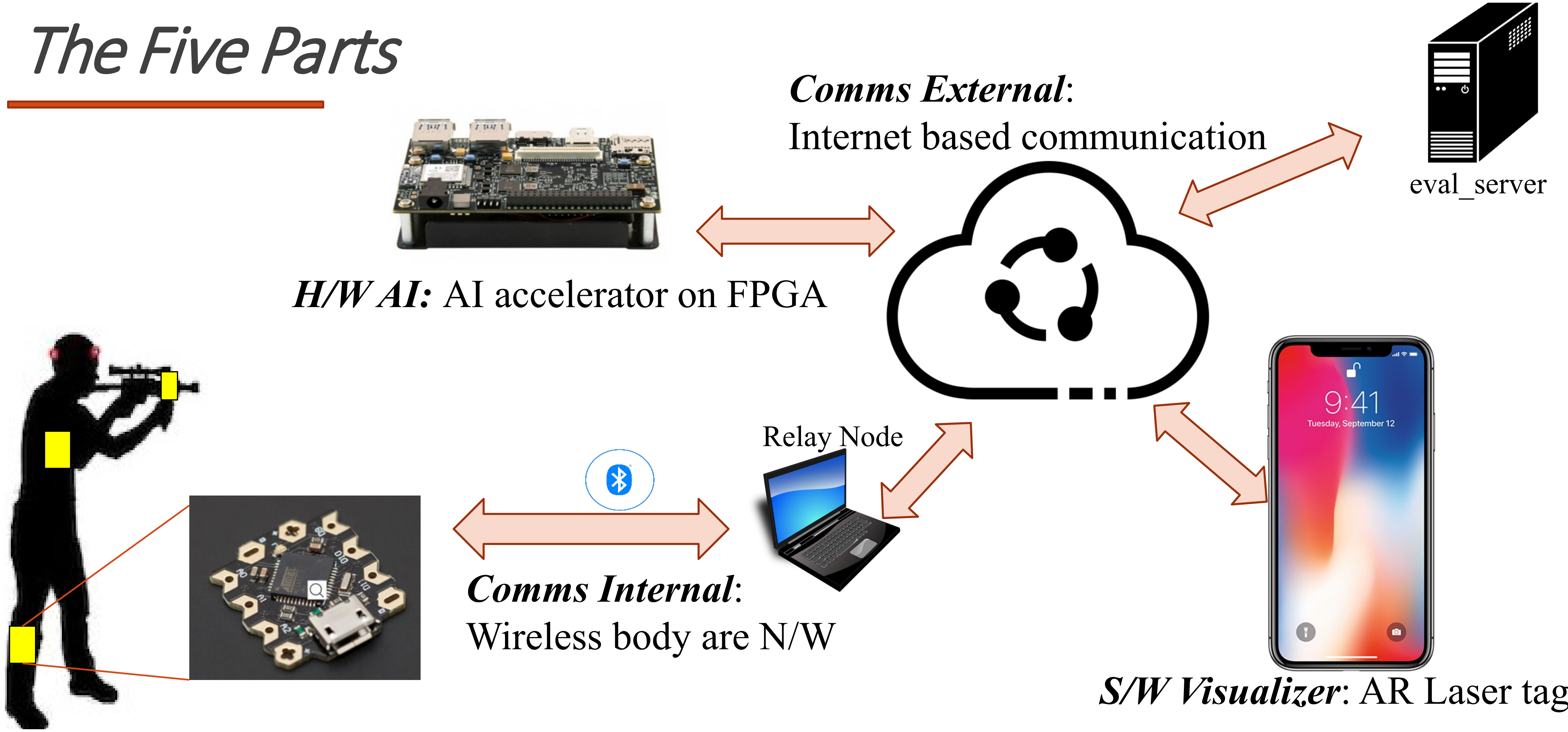
Rules

- Health Point
  - Player: 100 HP.
  - Shield: 30 HP/10 Sec
- Damage
  - Bullet: 10 HP
  - Grenade: 30 HP

Rules

- Ammo and constraints
  - Unlimited magazines
    - 6 bullets per magazine
    - Reload can be performed only if the magazine is empty
  - 2 grenades per life
  - 3 shields per lifetime
    - Cannot activate shield within 10 sec of previous activation, even if 0-HP
  - Delays
    - Grenade impact has 2 Sec delay on Visualizer
    - Rebirth is instantaneous

The Five Parts



Comms External: Internet based communication

eval_server

H/W AI: AI accelerator on FPGA

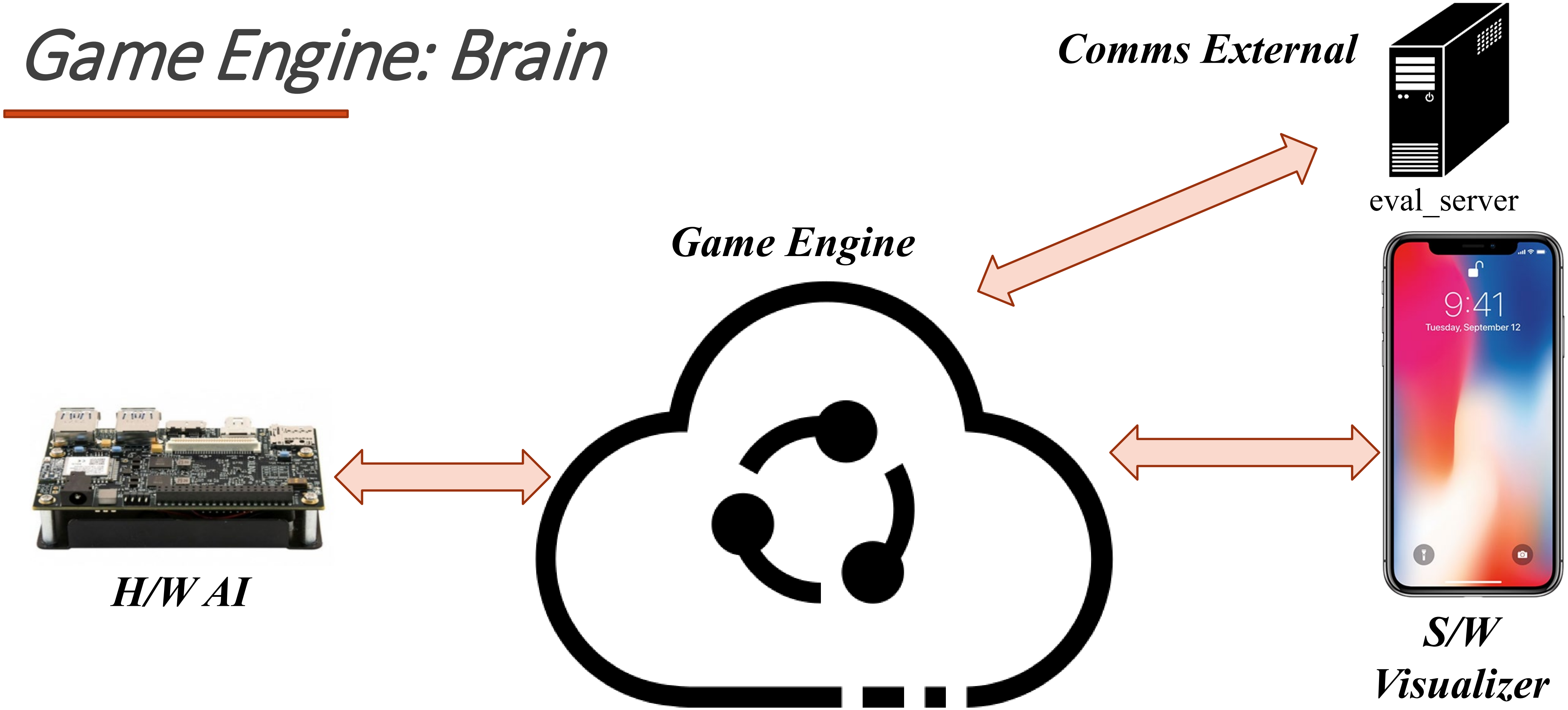
Relay Node

Comms Internal: Wireless body are N/W

S/W Visualizer: AR Laser tag

H/W sensors: Laser tag gun, target, sensors

Game Engine: Brain



Comms External

eval_server

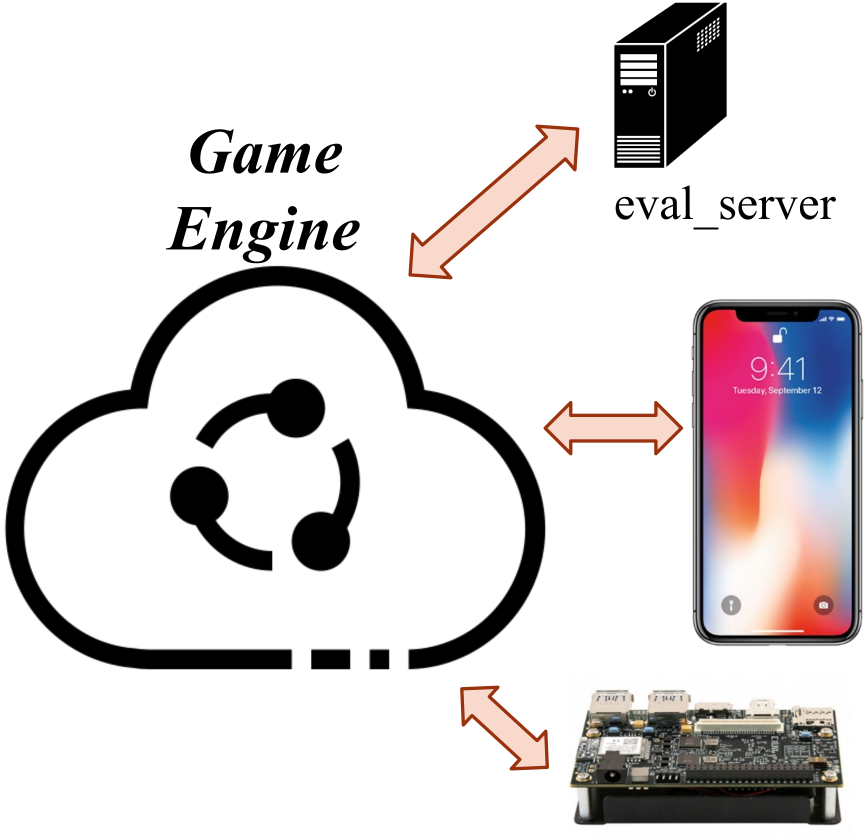
Game Engine

H/W AI

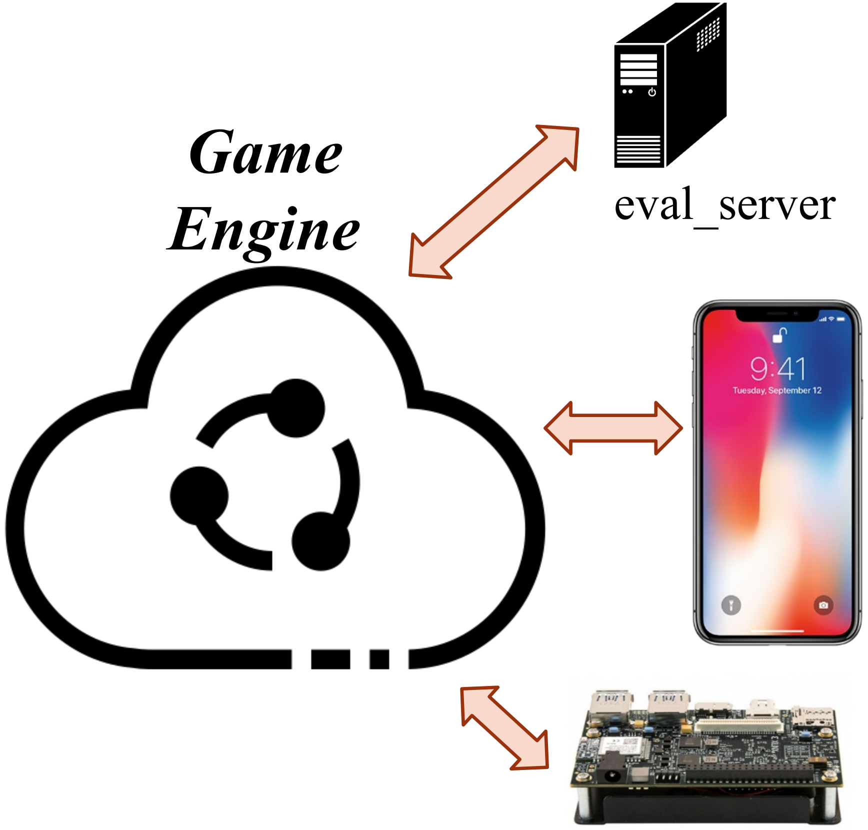
S/W Visualizer

Game Engine: Coordination

- AI
  - Receive the Detected Actions (including Shoot)
  - Update player info (HP, Ammo, shield time, etc.)
  - Send the information to Visualizer
  - Decide on when to send actions to Eval Server
    - May need a Barrier
- Eval Server
  - Receive and update game state
  - Send the updated information to Visualizer
- Visualizer
  - Receive player detection information (for Grenade)
  - Process inputs from the APP



Game Engine: Design

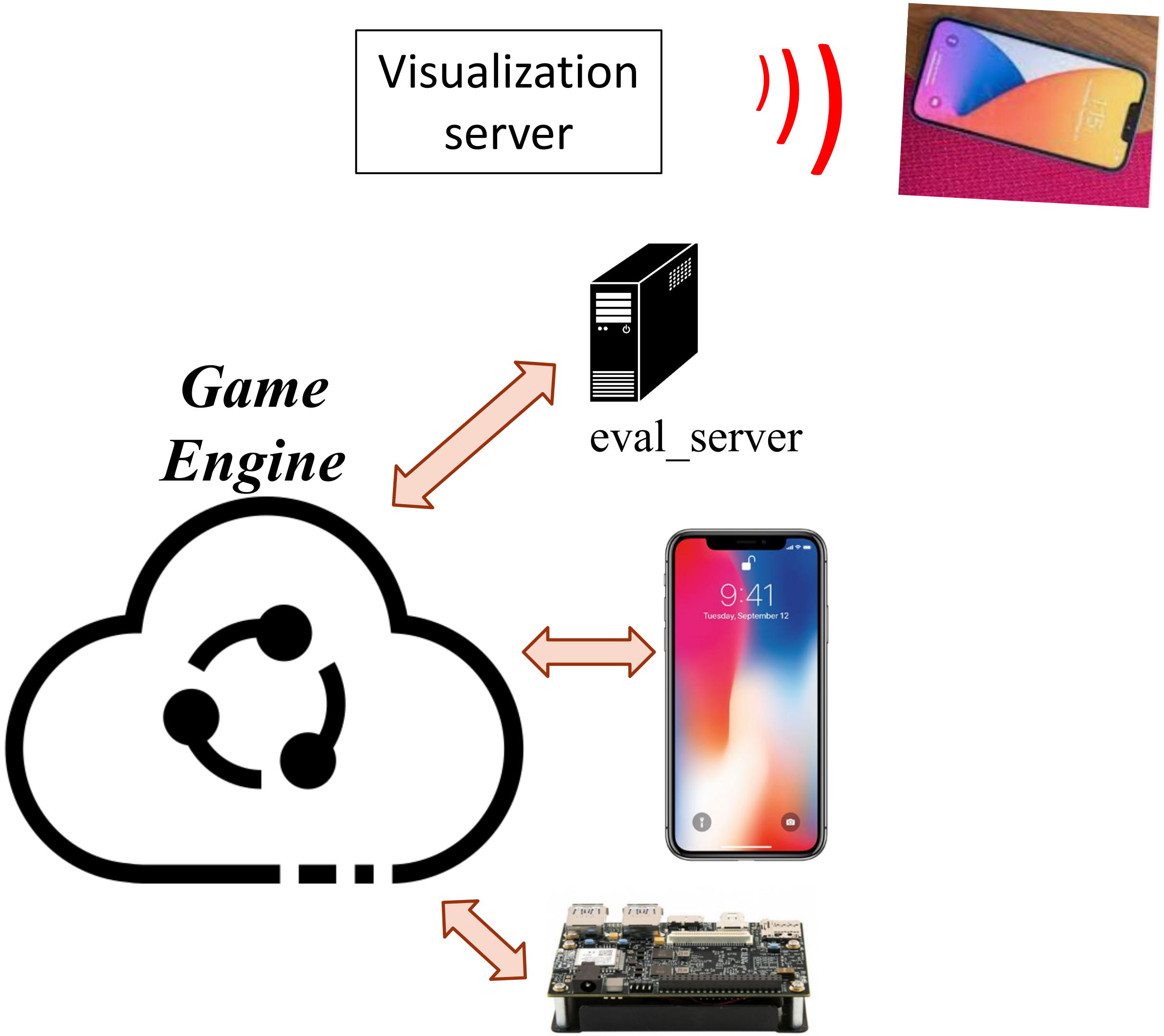


- Should be Multi-Threaded
- Threads need to be synchronized
  - Events serialization
  - Barrier
  - Buffer clearing
- Graceful Failure
  - Should continue to function even if a few components fail
- Resilient (***not graded***)
  - Should have capability to restart each components

Individual subcomponent test

- Visualizer
  - Design choices
    - Aesthetics
    - Functionality
  - Demo

- Game Engine
  - Design
  - Demo



Visualization server

Game Engine

eval_server