Controlling robots via the cloud

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Executive Summary

Controlling a robot is simple as long it is directly connected to the internet and has a public and reachable IP address. However, for most devices behind firewalls and NAT routers, this is not the case. Although there are mechanisms to open ports in these firewalls, this is not advisable from a security standpoint and often impossible in professional environments. The same applies to remote control devices, especially if they are connected via mobile phone networks.

To get around this problem, we propose to use a cloud service with a public and reachable IP address to relay data between a robot and a remote control device. This cloud service is based on Azure services.

To provide initial registration, identification, authorization and directory services, we implemented an API service where every robot can register itself.

To transmit video, sensor and control data with low latency, we implemented a communication service based on ASP.net SignalR.

Upon registration, the API service returns connection credentials to an Azure IoT hub and to the SignalR communication service to registering robots. These then establish a permanent connection to the IoT hub and receive further commands via the Cloud-to-Device messaging function of Azure IoT Hub.

When a remote control device wants to control a robot, it queries the directory service via the API service. A list of robots is returned that the remote control device is authorized to control. To establish a control channel, the remote control device then calls the API service again. The API service then sends a control message to the robot, instructing it to establish a connection to the SignalR communication service. Then the API service returns connection credentials for the SignalR communication service to the calling remote control device. It then also establishes a connection to the SignalR communication service. Now the robot sends video and sensor data to the communication service and the remote control device sends its control commands to the communication service.

As all connections in this architecture are always outgoing from the devices to the cloud, they can traverse firewalls and NAT routers and even work with mobile phone networks without problems.

Architecture Diagram

Robot

Microsoft Azure

Control App

Register Robot

Enable Robot Control

Azure IoT Hub Proxy Service

IOT Hub & SignalR Credentials

SignalR Credentials

Azure SQL database

IOT Hub Connection

IoT Hub

establish SignalR connection

SignalR Video and Control Connection

SignalR Video and Control Connection

ASP.NET SignalR

redis