Monitoring and Maintenance of Industry 4.0 Learning Laboratory using Digital Twin and Simultaneous OTA Updates

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Contents

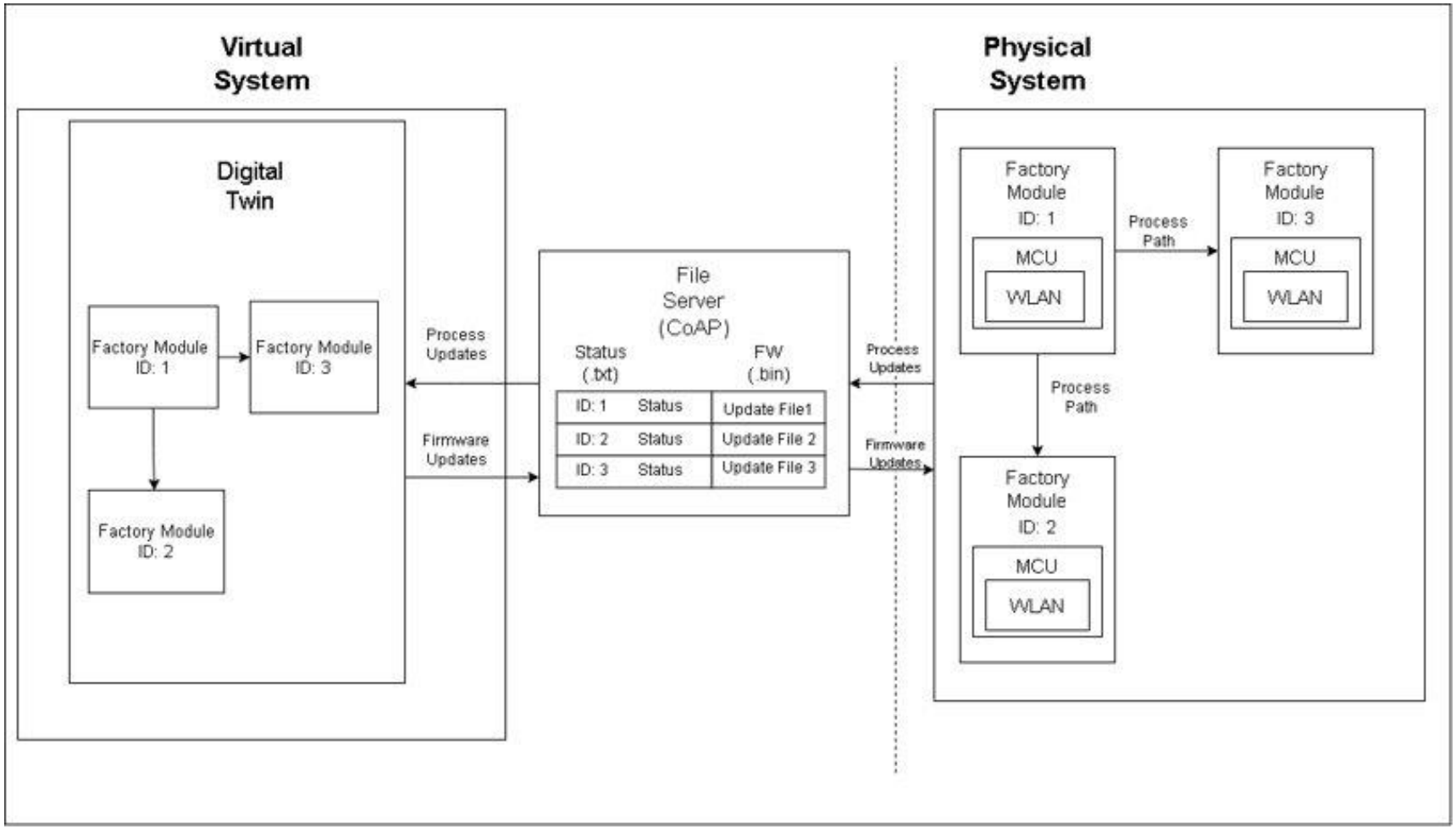
Introduction

Aim of the thesis: Proof of concept for the development of a monitoring and maintenance system for smart factories using Digital Twin and Simultaneous Firmware Updates

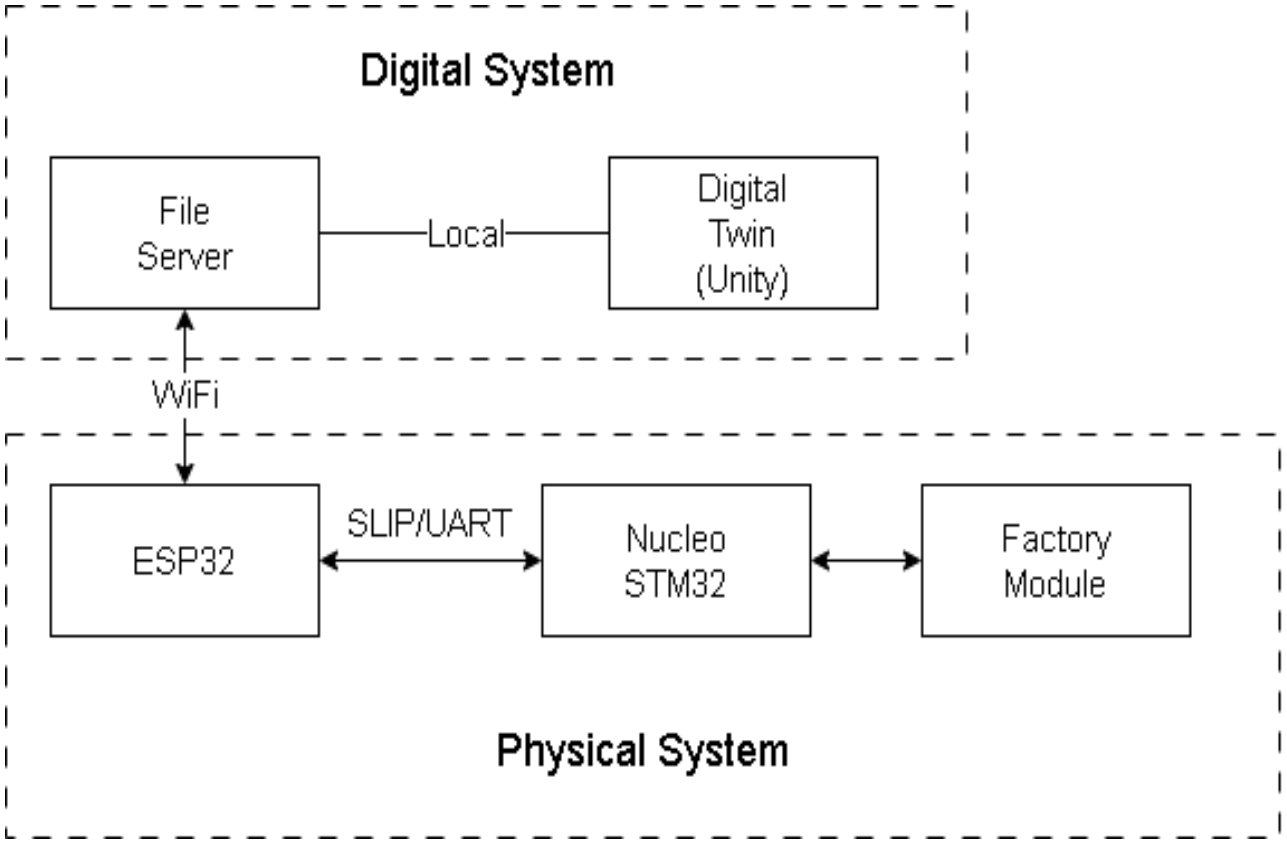
Proposed Tasks:

- Setup a layout consisting of various factory modules and establish wireless communication between them
- Develop a Digital Twin for virtual representation of the physical system and enable real-time tracking of the processes run by the system
- Enable simultaneous firmware updates for the system
- Measure the efficiency of the proposed system by measuring machine downtime during firmware updates and firmware update success rate

Conceptual Model

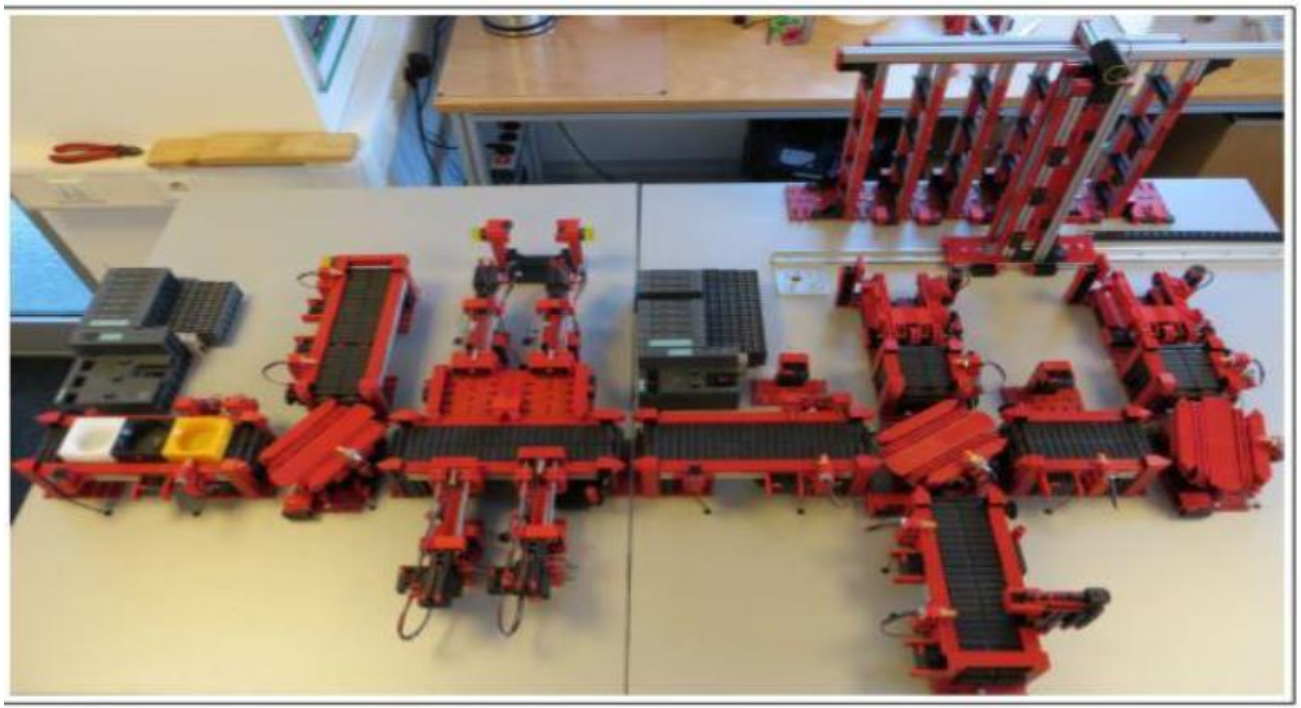


Development Architecture



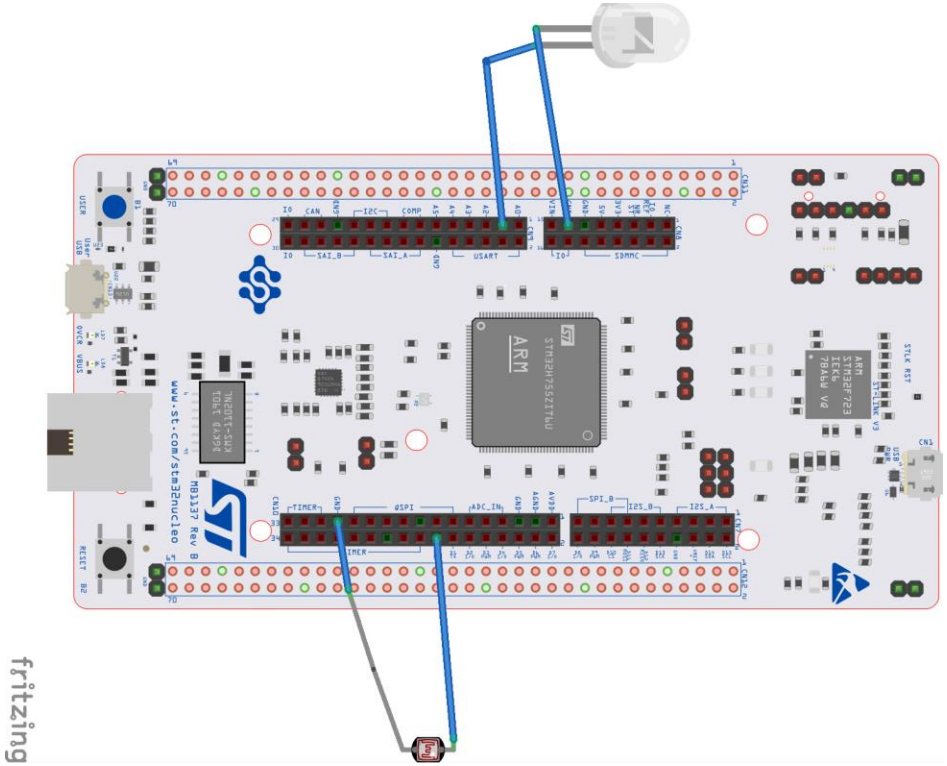
Experimental Setup

- Fischertechnik Factory Modules available in the Industry 4.0 Learning Laboratory at ILM OvGU
- Modules divided into Production and Dispatch Zones
- LiFi communication between modules in the Production Zone
- RF communication between modules in the Dispatch Zone



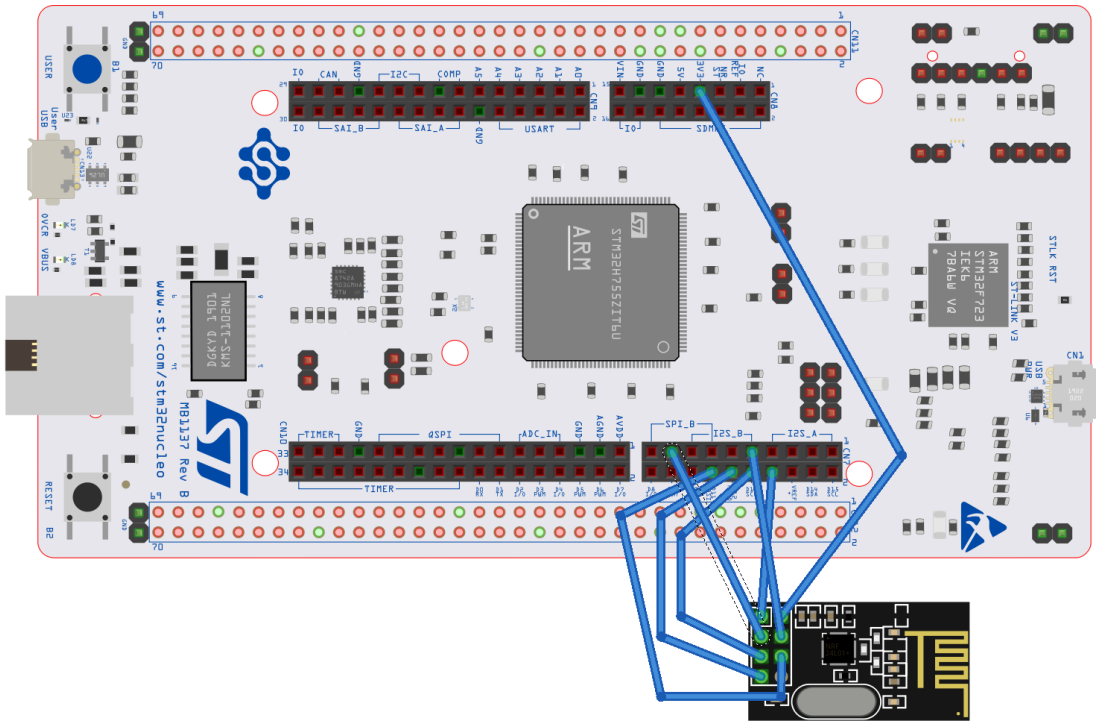
Production Zone Development

- LiFi Communication between the modules
- Three conveyors representing three production lines, one turntable to collect all outgoing workpieces, and a slider acting as a bridge between the production and dispatch areas



Dispatch Zone Development

- RF Communication between the modules
- Three conveyors representing three sinks, one turntable to collect all incoming workpieces, and a slider acting as a bridge between the production and dispatch areas



Tracking System

- Built a CoAP message sent to fileserver
- CoAP message contains json string containing status of all available module parameters

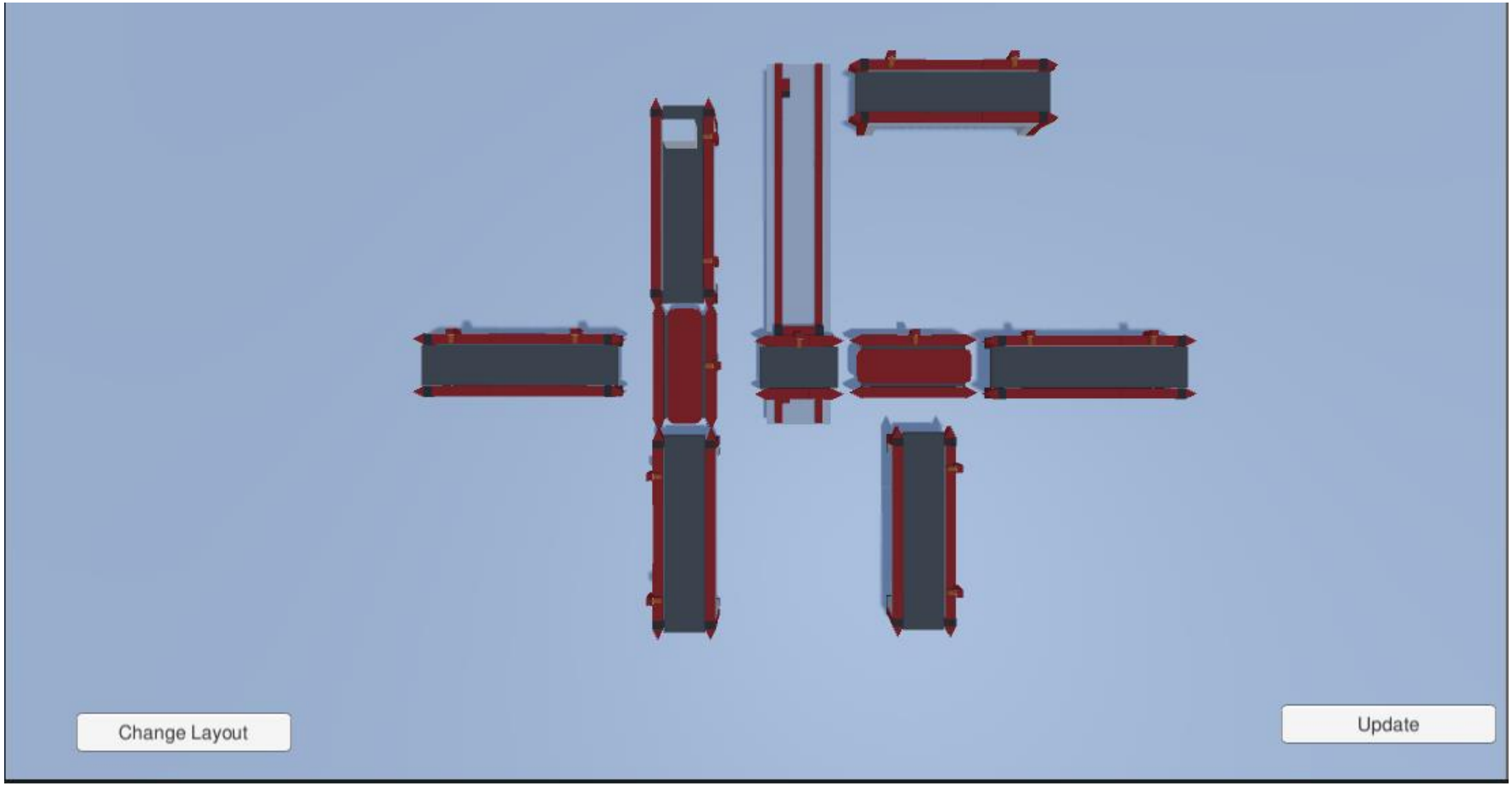
```
ssize_t hdrlen = coap_build_hdr(pkt.hdr, COAP_TYPE_CON, &token[0], 2,
                                3, 1);
coap_pkt_init(&pkt, &buf[0], buflen, hdrlen);
coap_opt_add_string(&pkt, COAP_OPT_URI_PATH, filePath, '/');
    coap_opt_add_uint(&pkt, COAP_OPT_CONTENT_FORMAT, COAP_FORMAT_TEXT);
    len = coap_opt_finish(&pkt, COAP_OPT_FINISH_PAYLOAD);

    pkt.payload_len = strlen(payload);
    memcpy(pkt.payload, payload, pkt.payload_len);
    len += pkt.payload_len;
        free(payload);


printf("nanocli: sending msg ID %u, %u bytes\n", coap_get_id(&pkt),
       (unsigned) len);

ssize_t res = _send(&pkt, buflen, serverAddr, serverPort);
if (res < 0) {
    printf("nanocli: msg send failed: %d\n", (int)res);
}
else {
    char *class_str = (coap_get_code_class(&pkt) == COAP_CLASS_SUCCESS)
                                ? "Success" : "Error";
    printf("nanocli: response %s, code %1u.%02u", class_str,
           coap_get_code_class(&pkt), coap_get_code_detail(&pkt));
```

```
1 {"fS":"0","sS":"0","fSw":"0","sSw":"0","mD":"f","tD":"ccl","sD":"f","iM":"0","iT":"0","iS":"0"}
```

Digital Twin

- Unity-based Simulation Model to replicate the physical system
- Reads the message sent to CoAP fileserver every second and replicates the motion and status of the modules in the simulation model
- Contains buttons to change layout and update the firmware of factory modules

Digital Twin



Firmware Updates

- Digital Twin contains button to update factory layout
- Update button runs script to notify the factory modules about new firmware to be installed
- Separate thread running in the microcontroller node interrupts the ongoing process to download the new firmware and flash itself

Tasks Remaining

Three experiments planned

- Module uptime to measure workload
- Module vs total runtime to measure system efficiency and detect bottlenecks
- Firmware Update Success Rate

Current Problems

- WiFi network setup is not possible due lack of ipv6 provision in the university network.
- WiFi to SLIP connection issues due to lack of support in RIOT OS

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Thank You!