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Development of a flow injection micro analysis system using an ARM microcontroller with an interactive web-based interface

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Appendicies

1 Device JSON Parser

```
uint8_t configDevices(const char *configJSON) {
    //Clear previous device config
    clearDevices();

    //Setup devices according to JSON description
    //Create a JSON parser object
    MbedJSONValue jsonParser;

    //Parse the JSON string and store the result in jsonParser
    parse(jsonParser, configJSON);

    //Loop through the JSON, extracting the device configuration for each device ID
    for (uint8_t i = 0; jsonParser[i].hasMember((char *)"devID"); i++) {
        //Create variables to hold the extracted values
        uint16_t devID;
        uint16_t devPin1;
        short devPin2;
        std::string devType;
```

```
        //Caution - always check if the object contains the requested value before attempting to
access it, otherwise a hardfault occurs from trying to access invalid memory
        if (jsonParser[i].hasMember((char *)"devID")) {
            //Have to get the value as a string and then convert it to an integer due to
limitations with the JSON parser library
            devID = std::stoi(jsonParser[i]["devID"].get<std::string>());


            if (jsonParser[i].hasMember((char *)"devPin1")) {
                //Have to get the value as a string and then convert it to an integer due to
limitations with the JSON parser library
                devPin1 = std::stoi(jsonParser[i]["devPin1"].get<std::string>());


                if (jsonParser[i].hasMember((char *)"devPin2")) {
                    //Have to get the value as a string and then convert it to an integer due to
limitations with the JSON parser library
                    devPin2 = std::stoi(jsonParser[i]["devPin2"].get<std::string>());


                    if (jsonParser[i].hasMember((char *)"devType")) {
                        //Get the device type string
                        devType = jsonParser[i]["devType"].get<std::string>();


                        if (devType.find("perPump") != string::npos) {
                            //Create perPump object
                            devices[i] = new perPump(digitalOutputs[devPin1-1], devID);
```

```
                        } else if (devType.find("solValve") != string::npos) {
                            //Create solValve object
                            devices[i] = new solValve(digitalOutputs[devPin1-1], devID);

                        } else if (devType.find("sixValve") != string::npos) {
                            //Create sixValve object
                            devices[i] = new sixValve(digitalOutputs[devPin1-1],
digitalOutputs[devPin2-1], devID);

                        } else if (devType.find("switchValve") != string::npos) {
                            //Check if the switchvalve is working in one or two pin mode
                            if (devPin2 == -1) {
                                //Create switchValve object with one pin
                                devices[i] = new switchValve(digitalOutputs[devPin1-1], devID);
                            } else {
                                //Create switchValve object with two pins
                                devices[i] = new switchValve(digitalOutputs[devPin1-1],
digitalOutputs[devPin2-1], devID);
                            }
```

```
                        } else {
                            //Debugging, send the client information over serial
                            serialQueue.call(printf, "Error creating object, could not determine
device type, device ID: %d, device pin 1: %d, device pin 2: %d\n", devID, devPin1, devPin2);

                            //An error has occurred, signal failure to configure
                            return 1;
                        }

                    } else {
                        //Debugging, send the client information over serial
                        serialQueue.call(printf, "Error reading device pin 2, device ID: %d,
device pin 1: %d\n", devID, devPin1);

                        //An error has occurred, signal failure to configure
                        return 1;
                    }
```

```
                } else {
                    //Debugging, send the client information over serial
                    serialQueue.call(printf, "Error reading device pin 1, device ID: %d, device
pin 1: %d\n", devID, devPin1);

                    //An error has occurred, signal failure to configure
                    return 1;
                }
            } else {
                //Debugging, send the client information over serial
                serialQueue.call(printf, "Error reading device pin 1, device ID: %d\n", devID);

                //An error has occurred, signal failure to configure
                return 1;
            }
        } else {
            //Debugging, send the client information over serial
            serialQueue.call(printf, "Error reading device ID\n");

            //An error has occurred, signal failure to configure
            return 1;
        }
    }
```

```
    //No errors, signal success
    return 0;
}
```

2 Routine JSON Parser

```
uint8_t configRoutine(const char *configJSON, uint16_t routineID) {
    //Clear the routine vector of any previous timing information
    routine.clear();

    //Setup routines according to JSON description
    //Create a JSON parser object
    MbedJSONValue jsonParser;

    //Parse the JSON string and store the result in jsonParser
    parse(jsonParser, configJSON);

    //check for name/ID of routine
    //check for timings array
    //loop through array, extracting timing data

    //Loop through all of the routines that have an valid ID
    for (uint8_t i = 0; jsonParser[i].hasMember((char *)"routineID"); i++) {
```

```
        //Caution - always check if the object contains the requested value before attempting to
access it, otherwise a hardfault occurs from trying to access invalid memory
        //Get the current routine ID
        if (jsonParser[i].hasMember((char *)"routineID")) {
            uint16_t currentRoutineID =
std::stoi(jsonParser[i]["routineID"].get<std::string>());


            //If the current iteration is the requested routine ID, load the data into the
vector
            if (routineID == currentRoutineID) {


                //Check if the timings array is present
                if (jsonParser[i].hasMember((char *)"timings")) {


                    //Loop through the timings array, extracting timing info
                    for (uint16_t j = 0; jsonParser[i]["timings"][j].hasMember((char *)"devID");
j++) {
                        //Create a variable to hold the extracted values
                        deviceTimes time;
```

```
                        //Check for the deviceID
                        if (jsonParser[i]["timings"][j].hasMember((char *)"devID")) {
                            //Have to get the value as a string and then convert it to an
integer due to limitations with the JSON parser library
                            time.devID =
std::stoi(jsonParser[i]["timings"][j]["devID"].get<std::string>());


                            //Check for the start time
                            if (jsonParser[i]["timings"][j].hasMember((char *)"timeStart")) {
                                //Have to get the value as a string and then convert it to an
integer due to limitations with the JSON parser library
                                time.startTime =
std::stoi(jsonParser[i]["timings"][j]["timeStart"].get<std::string>());


                                //Check for the stop time
                                if (jsonParser[i]["timings"][j].hasMember((char *)"timeStop")) {
                                    //Have to get the value as a string and then convert it to
an integer due to limitations with the JSON parser library
                                    time.stopTime =
std::stoi(jsonParser[i]["timings"][j]["timeStop"].get<std::string>());
```

```
                                    //Check for the device state
                                    if (jsonParser[i]["timings"][j].hasMember((char *)"state"))
{
                                        //Have to get the value as a string and then convert it
to an integer due to limitations with the JSON parser library
                                        time.devState =
std::stoi(jsonParser[i]["timings"][j]["state"].get<std::string>());


                                        //Add the timing information to the routines vector
                                        routine.emplace_back(time);
                                    } else {
                                        //Debugging, send the client information over serial
                                        serialQueue.call(printf, "Error reading the device
state, device ID: %d, start time: %d, stop time: %d\n", time.devID, time.startTime,
time.stopTime);


                                        //An error has occurred, signal failure to load the
routine
                                        return 1;
                                    }
                                } else {
                                    //Debugging, send the client information over serial
                                    serialQueue.call(printf, "Error reading the stop time,
device ID: %d, start time: %d\n", time.devID, time.startTime);
```

```
                                    //An error has occurred, signal failure to load the routine
                                    return 1;
                                }
                            } else {
                                //Debugging, send the client information over serial
                                serialQueue.call(printf, "Error reading the start time, device
ID: %d\n", time.devID);

                                //An error has occurred, signal failure to load the routine
                                return 1;
                            }
                        } else {
                            //Debugging, send the client information over serial
                            serialQueue.call(printf, "Error reading device ID\n");

                            //An error has occurred, signal failure to load the routine
                            return 1;
                        }
                    }
                    //Routine loaded, signal success
                    return 0;
```

```
                } else {
                    //Debugging, send the client information over serial
                    serialQueue.call(printf, "Error reading the timings array, Routine ID:
%d\n", currentRoutineID);

                    //An error has occurred, signal failure to load the routine
                    return 1;
                }
            }
        } else {
            //Debugging, send the client information over serial
            serialQueue.call(printf, "Error reading routine ID\n");

            //Cannot read routine ID, signal failure
            return 1;
        }
    }
```

```
    //Debugging, send the client information over serial
    serialQueue.call(printf, "No routine found matching the requested ID, %d\n", routineID);

    //No routine found with given ID, signal failure
    return 1;
}
```

3 Routine Duration Function

```
uint16_t routineDuration(void) {

    uint16_t duration = 0;

    //Loop through the timings array and look for the largest value of timeStop
    for (deviceTimes n : routine) {
        //If the stop time for the current step is greater than any previous stop time
        if (n.stopTime >= duration) {

            //Update the last time value with the new greatest value
            duration = n.stopTime;
        }
    }
    return duration;
}
```

4 Testing Devices Function

```
$(document).on("click", "button.btnTstDevices", function (event) {

    //Get the ID of the selected routine
    var routineID = $('select[id="routines_dropdown"] option:selected').attr('class');

    //Check if a valid routine has been selected
    if (typeof routineID == "undefined") {
        //Tell the user to select a valid device
        alert("Please select a routine, or create one if none are available");
        //Return and do not execute the rest of the function as there is an invalid input
        return 0;
    }

    //Define the URL to hit
    var reqURL = '/testdevices/routineid=' + routineID;
```

```
    //Send the AJAX request to the defined URL
    $.ajax({
        type: "GET",
        url: reqURL,
        //On success, alert the user
        success: function (result) {
            alert('Device test successful');
        },
        //On failure, alert the user
        error: function (result) {
            alert('There is an issue with testing a device');
        }
    });
});
```

5 Microcontroller Device Configuration Update

```
function updateDeviceConfig() {

    //Declare a local variable to hold the JSON as a string
    let devicesJSON = [];

    //Open our object store
    let objectStore = db.transaction('devices').objectStore('devices');

    //Get a cursor list of all the different data items in the IDB to iterate through
    objectStore.openCursor().onsuccess = function (event) {
        //Get the cursor
        let cursor = event.target.result;

        //If there is still another device, keep running
        if (cursor) {
```

```
            //Build the json for the device
            let device = {
                devID: cursor.value.devID,
                devName: cursor.value.devName,
                devType: cursor.value.devType,
                devPin1: cursor.value.devPin1,
                devPin2: cursor.value.devPin2
            };

            //Push the devices onto the array
            devicesJSON.push(device);

            //Continue to the next item in the cursor
            cursor.continue();

            //If all the devices have been read, send the updated config to the MCU
        } else {
            //Define the URL to hit with the updated configuration
            var reqURL = '/updatedevices/' + JSON.stringify(devicesJSON);
```

```
            //Send the AJAX request to the defined URL
            $.ajax({
                type: "GET",
                url: reqURL,
                //On success, refresh the page
                success: function (result) {
                    window.reload();
                },
                //On failure, alert the user
                error: function (result) {
                    alert('There was an issue adding the device');
                }
            });
        }
    }
}
```

```
else if (address.find("updatedevices/") != string::npos) {

            //Find the start of the config JSON
            int configStart = address.find("updatedevices/");

            //Get the config string
            string newDevConfig = address.substr(configStart + 14);

            //Attempt to update the device configuration
            if (configDevices((char *)newDevConfig.c_str())) {
                //An error occuraed with updating the configuration, add a 404 header code to
the response
                response += HTTP_STATUS_LINE_404;

                //Add a line feed and carriage return to the response
                response += "\r\n";
            }
```

```
            else {
                //Success, add a 200 header code to the response
                response += HTTP_STATUS_LINE_200;

                //Add a line feed and carriage return to the response
                response += "\r\n";
            }

        }
```

6 Routine Timing Visualisation

```
function genVisHTML(timings) {


    //Parse timings JSON
    //Sort the timings array by start time
    //Create a unique list of the deviceIDs used in the routine buy using getUniqueDevices()
    //Create an array to hold the unique deviceID timing span blocks
    //Get the names of the devices using getDeviceName()
    //Loop through the timings array, generating the span blocks and appending to the specified
deviceID row
    //Append closing div tags to each device row
    //Concatenate the html together and return as .html
```

```
    //Try to parse the JSON, return an error is it cannot be parsed
    try {
        times = JSON.parse(timings);
    } catch (e) {
        //If there was an error parsing the JSON, return an error
        return {
            code: 1,
            msg: "There was a problem parsing the JSON string",
            devices: [],
        };
    }

    //Sort the timings by start time
    times.sort(sortByProperty("timeStart"));

    //Get a list of all devices used
    var uniqueDevices = getUniqueDevices(timings);
```

```
    //Check if failed - code non-zero
    if (uniqueDevices.code) {

        //Alert that an error occurred
        alert("Error getting the list of devices used");

        //Log specific error
        console.log(duration.msg);
    }

    //Create an array to store the html row data
    var htmlRows = [];
```

```
    //Loop through the unique devices, and create the initial row html
    for (ij in uniqueDevices.devices) {

        //Attempt to get the device name from the deviceID
        let devName = getDeviceName(uniqueDevices.devices[ij]);

        //Check if failed - code non-zero
        if (devName.code) {

            //Alert that an error occurred
            alert("Error getting device name");

            //Log specific error
            console.log(devName.msg);
        }

        //Initialise the row with the name of the device and the class for the chart
        htmlRows[ij] = '<div class="row"> <h6>' + devName.name + '</h6><div class="chart">';
    }
```

```
    //Attempt to get the duration of the routine
    var duration = getDuration(timings);

    //Check if failed - code non-zero
    if (duration.code) {

        //Alert that an error occurred
        alert("Error getting the duration of the routine");

        //Log specific error
        console.log(duration.msg);
    }
```

```
    //Loop through the timings array and generate the span blocks
    for (ik in times) {

        //Get the type of the device
        var deviceType = getDeviceType(times[ik].devID);

        //Check if failed - code non-zero
        if (deviceType.code) {

            //Alert that an error occurred
            alert("Error getting the type of the device");

            //Log specific error
            console.log(deviceType.msg);
        }
```

```
        //Get the pretty name of the current state
        var pName = getPrettyState(times[ik].state, deviceType.type);

        //Check if failed - code non-zero
        if (pName.code) {

            //Alert that an error occurred
            alert("Error getting the pretty name of the current state");

            //Log specific error
            console.log(pName.msg);
        }
```

```
        //Calculate the width of the block in the figure, in %
        //Calculate the duration of the block
        var stepDur = times[ik].timeStop - times[ik].timeStart;

        //Convert this to the width of the block by multiplying by 100/duration
        var blockWidth = stepDur * (100 / duration.dur);

        //Create visualisation HTML span
        var rowHTML = '<span style="width:' + blockWidth + '%;"class="block state' +
        pName.pState + '" title="' + times[ik].timeStart + '-' + times[ik].timeStop +
        ' seconds"><span class="dspState">' + pName.pState + '</span></span>';

        //If the deviceID can be found in the timings array, append the next span block to it
        if (uniqueDevices.devices.indexOf(parseInt(times[ik].devID)) != -1) {

            //Get the index of the deviceID row specified in the timings block
            let index = uniqueDevices.devices.indexOf(parseInt(times[ik].devID));

            //Append the new block to the existing HTML
            htmlRows[index] += rowHTML;
        }
    }
```

```
    //Loop through the unique devices, and append the closing div tags
    for (ji in uniqueDevices.devices) {

        //Append the closing div tags to each of the rows
        htmlRows[ji] += '</div></div>';
    }

    //Join the rows together into 1 string to return
    visHtml = htmlRows.join("");

    //Return the duration of the routine
    return {
        code: 0,
        msg: "Success",
        html: visHtml,
    };

}
```