Sistemi Lente/Prism

A Manufacturing Test Framework

The Problem…

- Startup/Small Company develops a product, builds a prototype…
  - Customer loves it, orders thousands, due in 3 months…
  - Time to build a test system…
- Can you afford/budget to outsource the development?
  - Did you write clean specs to transfer knowledge of your product to an outsource to get the job done (in time)?
  - Can your core developers support a 3rd party while they prepare for launch?
- Can you develop the test system yourself?
  - More software, another PCB design…
  - Most test systems are about as complicated as the product they test…
  - Databases, test look up, revision control, …

Sistemi Lente/Prism for In-House Test Development

- In-House development (advantages)
  - Core developers are present and engaged
    - Quicker answers to problems
    - Quicker changes to support production test
  - Technical details are known
    - No need to write detailed specs for external consumption
  - Transparent Scheduling

Sistemi Lente/Prism

- Provides a framework for a HW/SW Test Engineer to start developing a test system **WITHOUT**, worrying about the "plumbing"…
  - User Interface
  - Programming Language
  - Production Monitoring
  - Database
  - Version Control
  - Scalability
  - Deployment
  - …

Estimated to save 6-12 man-months of development for a decent manufacturing test system that has comparable features

4

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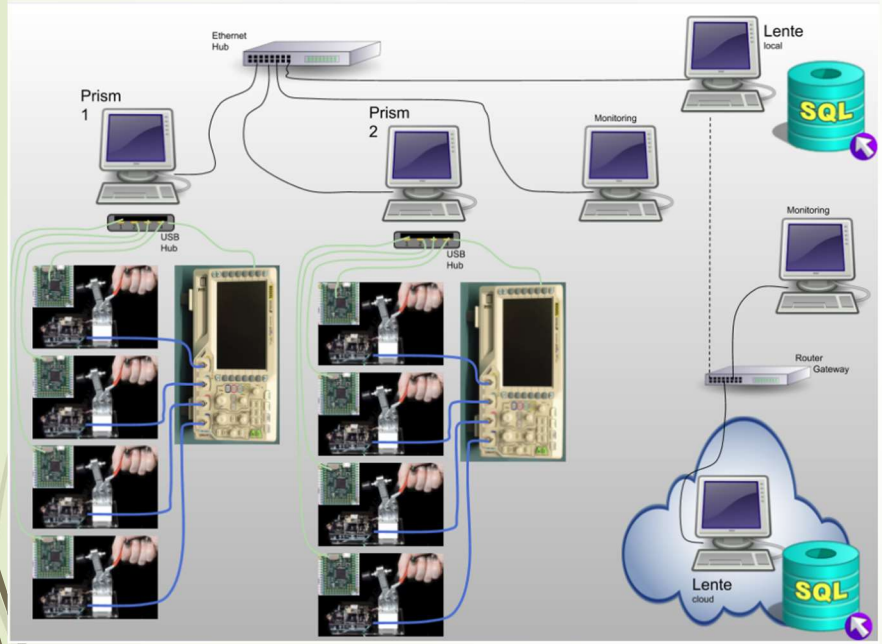


Provides a framework to develop production (or Engineering) test suites

Prism

- Runs Python (3.6) test code
- Easy API for collecting results, setting Pass/Fail
- Executes test code driven by JSON "script"
  - Human readable, a non-programmer can make changes

Lente

- Collects results from Prism stations
- Stores results in a SQL Database (extracts the JSON)
- Result traceability

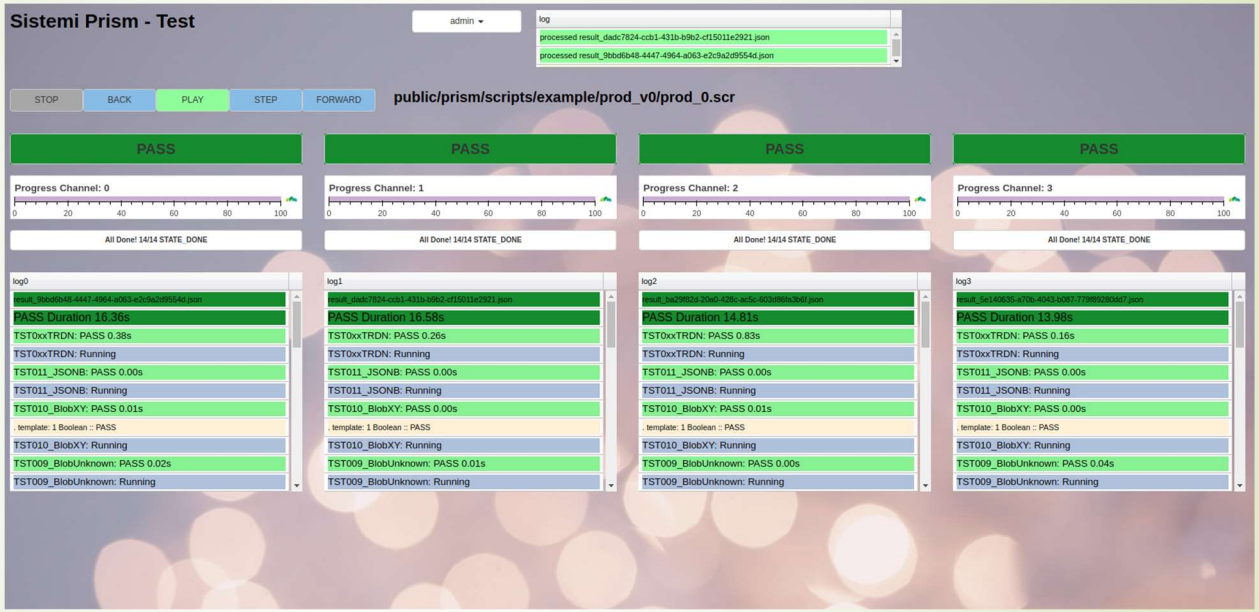
You worry about test code – Lente/Prism handles EVERYTHING else!

5

Lente/Prism Features

- JSON Test Scripts
  - Human readable, enable/disable tests, change limits
  - Non-programmer can make changes
- JSON Results
  - Human readable, easy to post process
- Result SQL Database
  - Dashboards and queries
- Python Codebase
  - Popular/easy programming
  - Multi-threaded for concurrency
- Traceability
  - Capture serial numbers, lot numbers, and any other identifier information from the DUT
  - All these identifiers go into SQL DB for query later
- Results stored in postgres SQL database which can be located anywhere (local, cloud, etc.)

Prism GUI: Testing Panel



- 4 Channels are shown
- Each channel is an independent thread

7

Result Server Dashboard

- Top Row selectors to sort data
  - Can view data from a single LOT#
- Select row of Pass/Fail tables to bring up the test record details
- Summary Tables
  - Results reflect Selector settings
  - Pass/Fail Counts
  - Top failed tests and counts
- Graphs to show trends
  - Test Duration and Pass/Fail Hourly Rate

8

JSON Test Scripts

- Drives the test bench
- Human readable
- Each test item as an "id", which corresponds to python function that implements the test
- Non-programmer can read this file and make changes

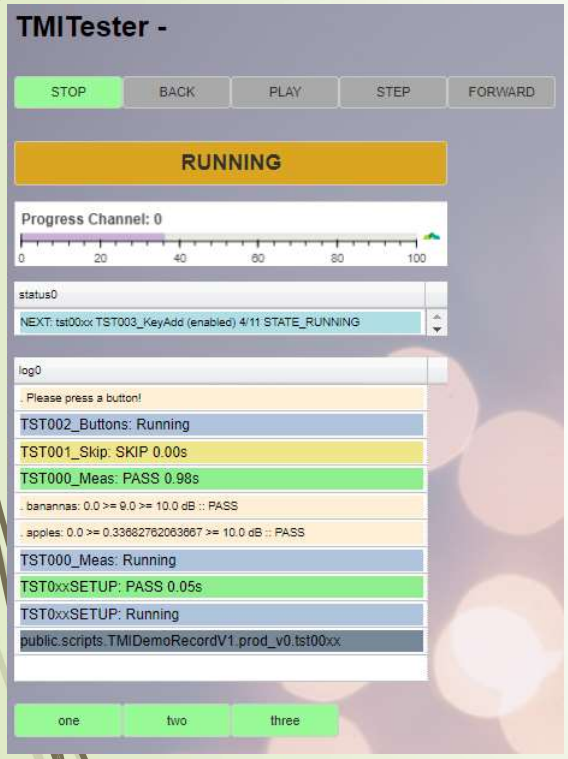
```
{
 "info": {
    "product": "widget_1",
    "bom": "B00012-001",
    "lot": "201823",
    "location": "site-A"
  },
  "config": {
    "channel_hw_driver": ["tmi_scripts.prod_v0.drivers.tmi_fake"]
  },
  "tests": [
    {
      "module": "tmi_scripts.prod_v0.tst00xx",
      "options": {
        "fail_fast": false
      },
      "items": [
        {"id": "TST0xxSETUP",           "enable": true },
        {"id": "TST000_Meas",           "enable": true, "args": {"min": 0, "max": 10},
                                        "fail": [ {"fid": "TST000-0", "msg": "Component apple R1"},
                                                  {"fid": "TST000-1", "msg": "Component banana R1"}] },
        {"id": "TST0xxTRDN",            "enable": true }
      ]
    },
    {
      "module": "tmi_scripts.prod_v0.tst01xx",
      "options": {
        "fail_fast": false
      },
      "items": [
        {"id": "TST1xxSETUP", "enable": true },
        {"id": "TST100_Meas", "enable": true,  "args": {"min": 0, "max": 11},
                              "fail": [ {"fid": "TST100-0", "msg": "Component R1"} ] },
        {"id": "TST100_Meas", "enable": true,  "args": {"min": 0, "max": 12},
                              "fail": [ {"fid": "TST100-0", "msg": "Component R1"} ] },
        {"id": "TST1xxTRDN",  "enable": true }
      ]
    }
  ]
}
```

Python Test Code

- Each test item from the JSON script (previous slide), is a python coded function
- APIs to make test driver code easy
  - Save any measurement
  - Get user input (buttons, text entry)
  - Set product keys (ex serial number)
  - Add logs
- NOTE: Not shown in the code snippet is code related to controlling your hardware to make measurements.

```
def TST000_Meas(self):
    """ Measurement example, with multiple failure messages
    - example of taking multiple measurements, and sending as a list of results
    - if any test fails, this test item fails

        {"id": "TST000_Meas",     "enable": true, "args": {"min": 0, "max": 10},
                                  "fail": [ {"fid": "TST000-0", "msg": "Component apple R1"},
                                            {"fid": "TST000-1", "msg": "Component banana R1"}] },
    :return:
    """
    ctx = self.item_start()   # always first line of test

    time.sleep(self.DEMO_TIME_DELAY * random() * self.DEMO_TIME_RND_ENABLE)

    FAIL_APPLE   = 0  # indexes into the "fail" list, just for code readability
    FAIL_BANANNA = 1

    measurement_results = []  # list for all the coming measurements...

    # Apples measurement...
    _result, _bullet = ctx.record.measurement("apples",
                                              random(),
                                              ResultAPI.UNIT_DB,
                                              ctx.item.args.min,
                                              ctx.item.args.max)
    # if failed, there is a msg in script to attach to the record, for repair purposes
    if _result == ResultAPI.RECORD_RESULT_FAIL:
        msg = ctx.item.fail[FAIL_APPLE]
        ctx.record.fail_msg(msg)

    self.log_bullet(_bullet)
    measurement_results.append(_result)

    # Bananas measurement...
    _result, _bullet = ctx.record.measurement("bananas",
                                              randint(0, 10),
                                              ResultAPI.UNIT_DB,
                                              ctx.item.args.min,
                                              ctx.item.args.max)

    # if failed, there is a msg in script to attach to the record, for repair purposes
    if _result == ResultAPI.RECORD_RESULT_FAIL:
        msg = ctx.item.fail[FAIL_BANANNA]
        ctx.record.fail_msg(msg)

    self.log_bullet(_bullet)
    measurement_results.append(_result)

    # Note that we can send a list of measurements
    self.item_end(item_result_state=measurement_results)  # always last line of test
```

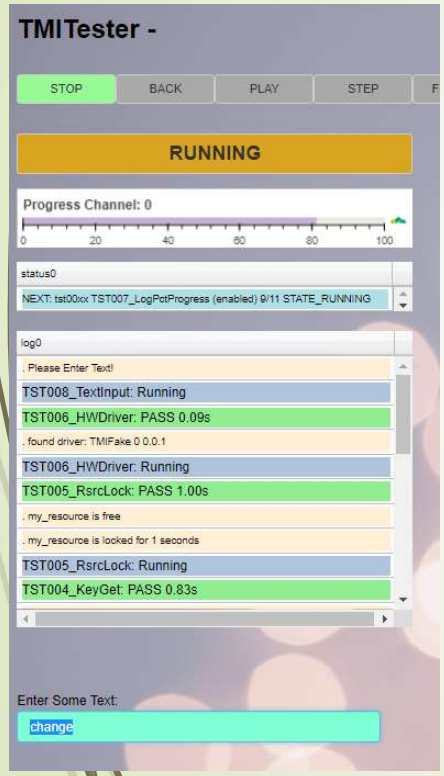
Python Test Code – User Buttons




```python
def TST002_Buttons(self):
    """ Select one of three buttons
    - capture the button index in the test record
    """
    ctx = self.item_start()   # always first line of test

    self.log_bullet("Please press a button!")

    buttons = ["one", "two", "three"]
    user_select = self.input_button(buttons)
    if user_select["success"]:
        b_idx = user_select["button"]
        self.log_bullet("{} was pressed!".format(buttons[b_idx]))
        _result, _bullet = ctx.record.measurement("button", b_idx, ResultAPI.UNIT_INT)
        self.log_bullet(_bullet)
    else:
        _result = ResultAPI.RECORD_RESULT_FAIL
        self.log_bullet(user_select.get("err", "UNKNOWN ERROR"))

    self.item_end(_result)  # always last line of test
```

- When a test requires Operator input, one option is buttons
- Shows is the Test panel presenting three buttons to the Operator

Python Test Code – Text Input



- For the case when text input is needed
  - Text input is NEVER a good thing for production environment, too slow and error prone
  - However this input is meant for **Barcode Scanners**, which can output text like a keyboard.
    - For example, scanning lot codes of parts used on a DUT

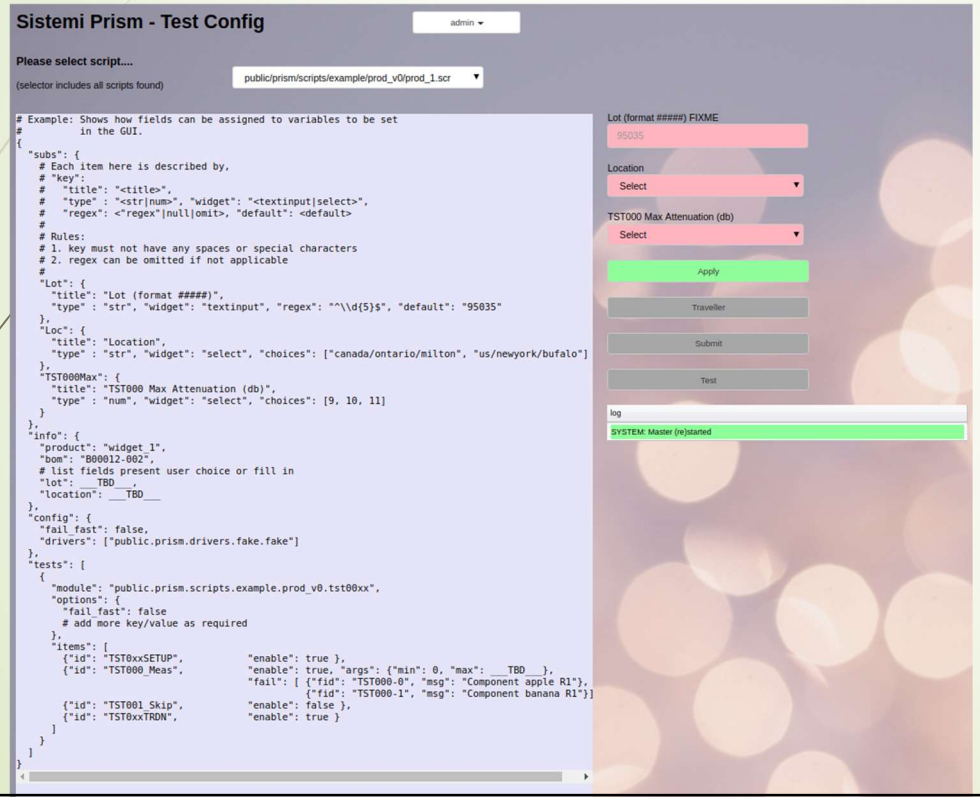
```
def TST008_TextInput(self):
    """ Text Input Box
    """
    ctx = self.item_start()   # always first line of test

    self.log_bullet("Please Enter Text!")

    user_text = self.input_textbox("Enter Some Text:", "change")
    if user_text["success"]:
        self.log_bullet("Text: {}".format(user_text["textbox"]))

        # qualify the text here,
        # make sure you don't timeout...

        _result = ResultAPI.RECORD_RESULT_PASS
    else:
        _result = ResultAPI.RECORD_RESULT_FAIL
        self.log_bullet(user_text.get("err", "UNKNOWN ERROR"))

    self.item_end(_result)  # always last line of test
```

JSON Results

- Human readable
  - Very useful in development; Can be encrypted
- Normalized, all results have the same structure, making it easier to process SQL in a standard way
- Each Result has unique RUID
- Measurement data "name" is a full path to the test
- Support for Postgres JSONB objects

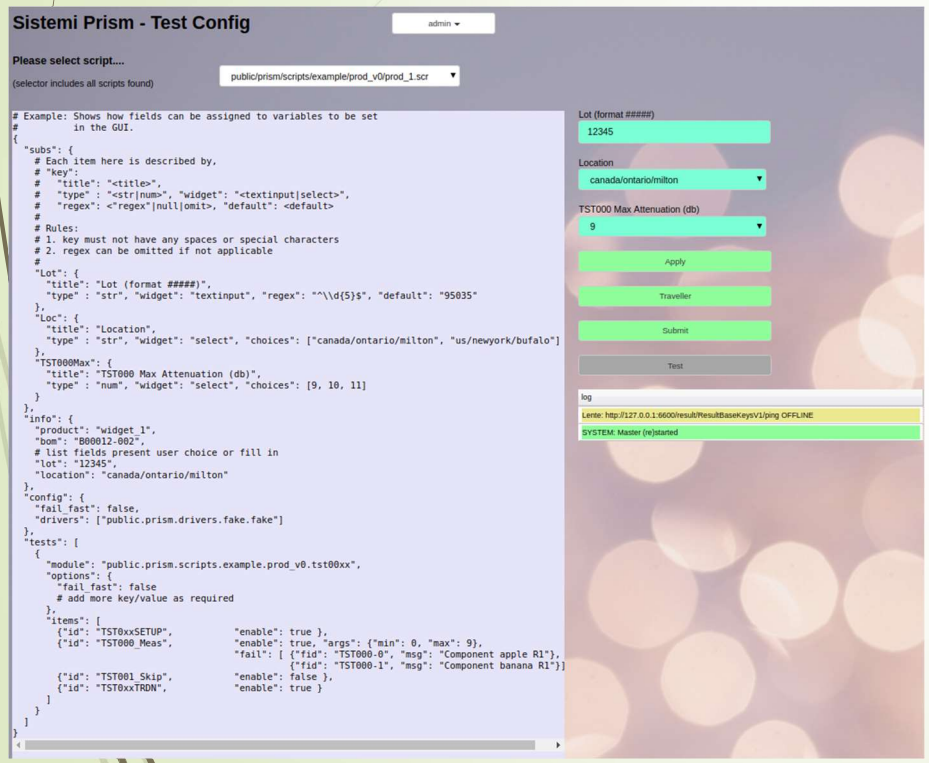

```
"result": {
  "meta": {
    "channel": 0,
    "result": "FAIL",
    "version": "TBD-framework version",
    "start": "2018-07-09T22:46:20.424386",
    "end": "2018-07-09T22:46:45.329920",
    "hostname": [
      "Windows",
      "DESKTOP-O6AMGKM",
      "10.0.17134",
      "AMD64",
      "Intel64 Family 6 Model 58 Stepping 9, GenuineIntel"
    ],
    "script": null
  },
  "keys": {
    "serial_num": 12345,
    "ruid": "0dc26c9a-909c-4df3-8c91-bfbe856d5ba2"
  },
  "info": {},
  "config": {},
  "tests": [
    {
      "name": "tests.example.example1.SETUP",
      "result": "PASS",        "timestamp_start": 1531176380.44,
      "timestamp_end": 1531176381.44,
      "measurements": []
    },
    {
      "name": "tests.example.example1.TST000",
      "result": "PASS",
      "timestamp_start": 1531176381.45,
      "timestamp_end": 1531176383.46,
      "measurements": [
        {
          "name": "tests.example.example1.TST000.apples",
          "min": 0,
          "max": 2,
          "value": 0.5,
          "unit": "dB",
          "pass": "PASS"
        },
        {
          "name": "tests.example.example1.TST000.banannas",
          "min": 0,
          "max": 2,
          "value": 1.5,
          "unit": "dB",
          "pass": "PASS"
        }
      ]
```

Prism GUI: Test Configuration (optional)



- Scripts "subs" section can define items that are to be set at test time
- For example,
  - Lot Number
  - Location
  - Measurement limits
- Definition controls user options
- Regex patterns are also supported for text entry fields

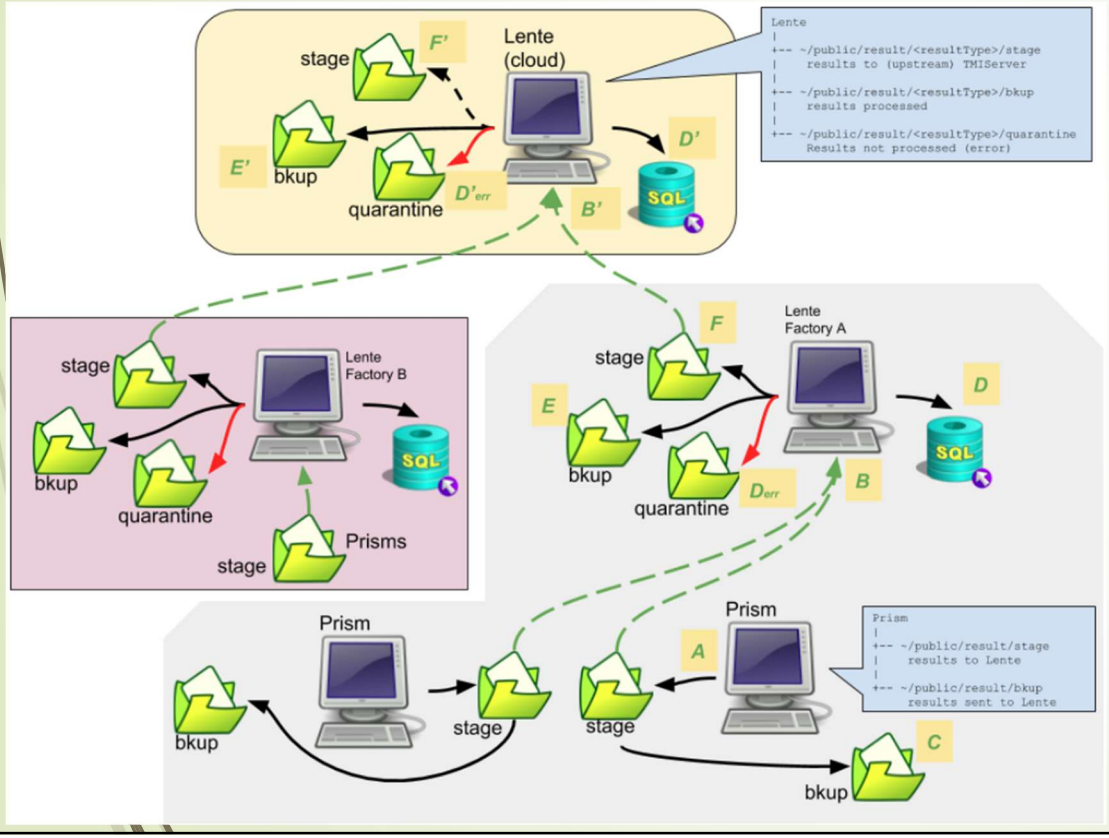
Prism GUI: Test Configuration Create Barcode (optional)



- Travellers can be made to capture all subs variables, and then scanned on the production floor
  - No manual entry by test operators

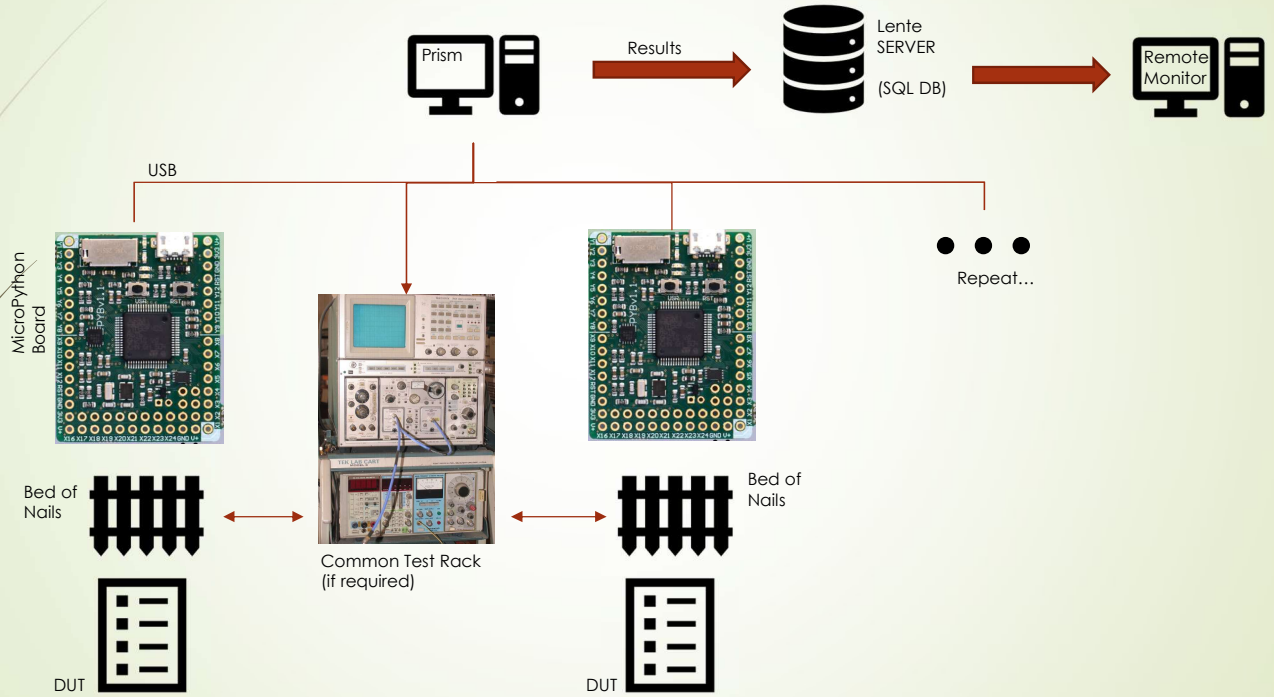
15

Lente/Prism: Result Flow

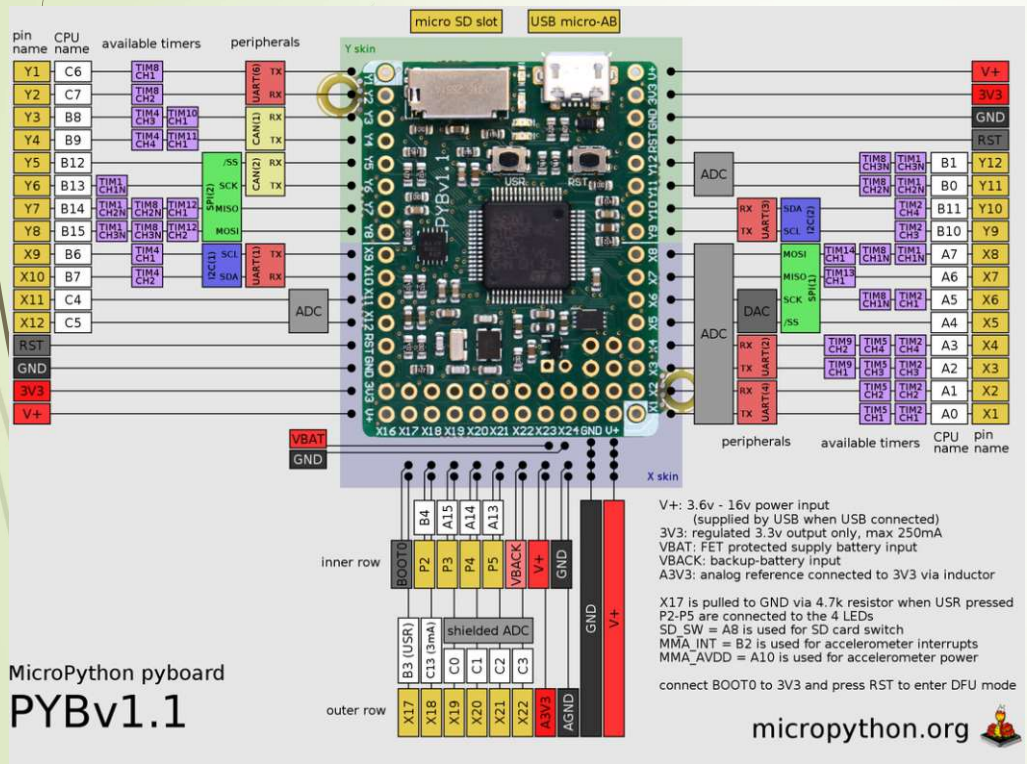


- (JSON) Result files flow upwards
- Backups are made along the way
- Any Lente can present a dashboard based on the results within its SQL DB
- Prism stations also back backup data

Example HW Block Diagram



MicroPython Test Instrument

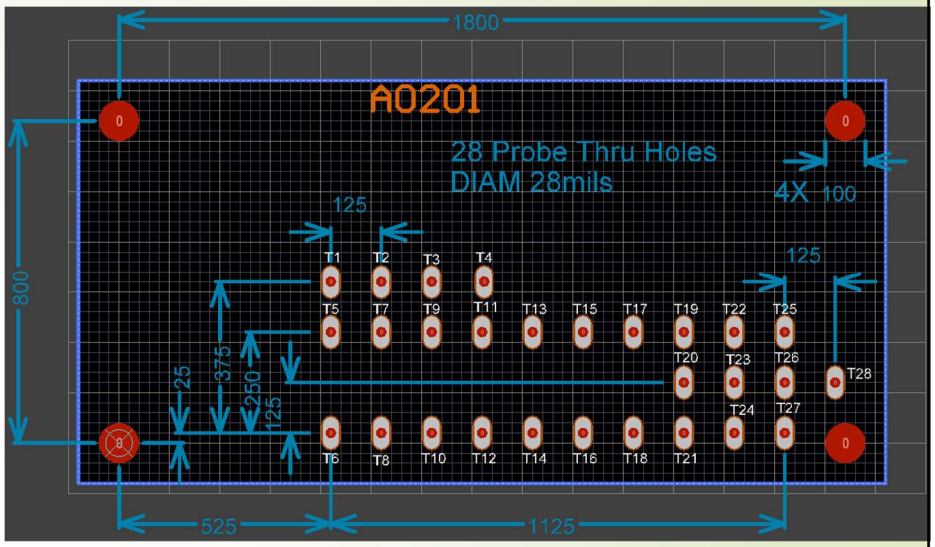


- Low Cost
- Read/Write GPIOs
- ADC
- Proxy for Serial, I2C, SPI commands

- NOTE: The MicroPython board may not be suitable for your application. This board is used to demonstrate and develop the features of the framework.

MicroPython Interface Proto Board v1.x

- Regardless of your PCB design, if you place test pads to **use any subset** of the 28 pads that are in this arrangement – then you can use this already designed Interface Board
- Any of the test points can be connected to the MicroPython board which can make ADC measurements, GPIO, UART, I2C and other functions
- This Interface board also supports 2 programmable Voltage rails and one current measurement sensor
- Your exact test point needs should be described and checked to see if they can be satisfied by the MicroPython Interface Board v1.x



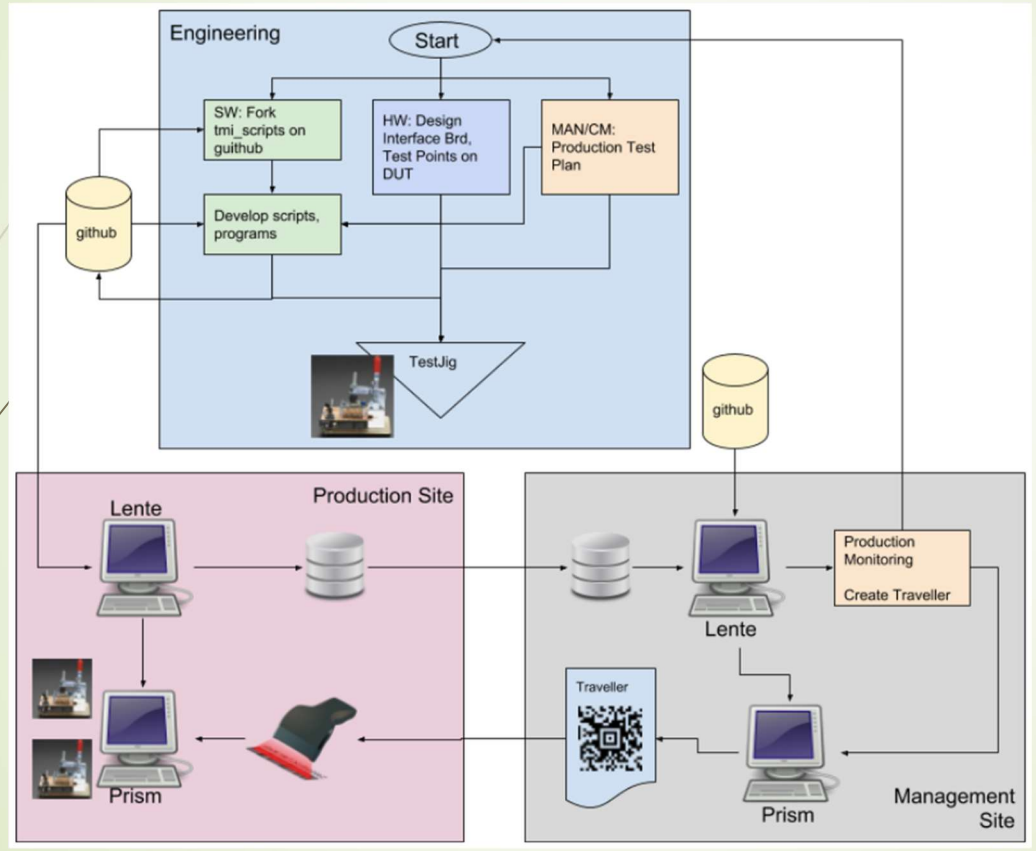
- The MicroPython Interface Board is available on CircuitMaker as a project that can be forked, modified for your requirements

DUT Design for Testability

- Add test points for the bed of nails jig
- Understand the MicroPython Board IO pin capabilities
  - Or create your own "interface board"
- Create PCB to interface MicroPython Board to the DUT
  - Or use the already designed MicroPython Board V1.x
- Determine what external test equipment is required to test things that can't be tested with MicroPython Board

- Write (Python 3.6) Software within this framework…
  - Results will be normalized, stored in SQL DB
  - Logging
  - Results Dashboard

Development/Production Model



Security

- Accounts
  - User assigned Roles for access to different system features
  - PWs stored encrypted
- Results
  - can be encrypted
- Prism station
  - Code/Scripts can be **"locked down"**, tests will not start if any locked down file has been altered
  - Travellers to control
    - what Script is run,
    - what variable parameters are used – production operator "hands free"

22

Project Current Status

- Ready to Demo
- Features in Development
  - More dashboard statistical graphs
  - More management tasks

23

Other

- DUT measurements
  - Considering the Diligent Analog Discover 2
    - 2CH (100Msample/sec) scope, GPIO, Power sources, Digital Bus Analyzers (SPI, I²C, UART, Parallel)
    - Python drivers
    - CON
      - $400 each!
      - No (serial, i2c, etc.) ports

24