

Combinatorial Testing Methodologies for IoT Hubs

Dimitris Simos, Bernhard Garn, Dominik Schreiber, Rick Kuhn, Raghu Kacker

Reducing Complexity for IoT Home Automation Systems with Combinatorial Methods

Research Problems

- ▶ The IoT industry is growing rapidly with estimations predicting, that 1 million IoT devices are going to be purchased and installed each hour in 2021.
- ▶ IoT devices are often controlled by a hub, to integrate devices using different protocols, e.g., z-wave, zigBee, Wi-Fi.
- ▶ Exhaustive IoT testing quickly becomes intractable for larger systems, because of many devices interacting with each other.

Combinatorial Testing

- ▶ Reduce test cases while still achieving good coverage.
- ▶ With interaction strength 5-6, usually all software bugs can be found.
- ▶ Modelling of IoT home automation systems.
- ▶ Generation of test cases with combinatorial methods.
- ▶ Automatic test oracle to determine, if the test was successful.

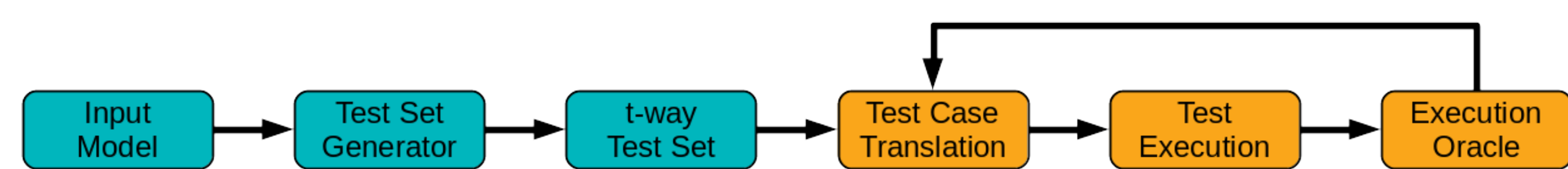
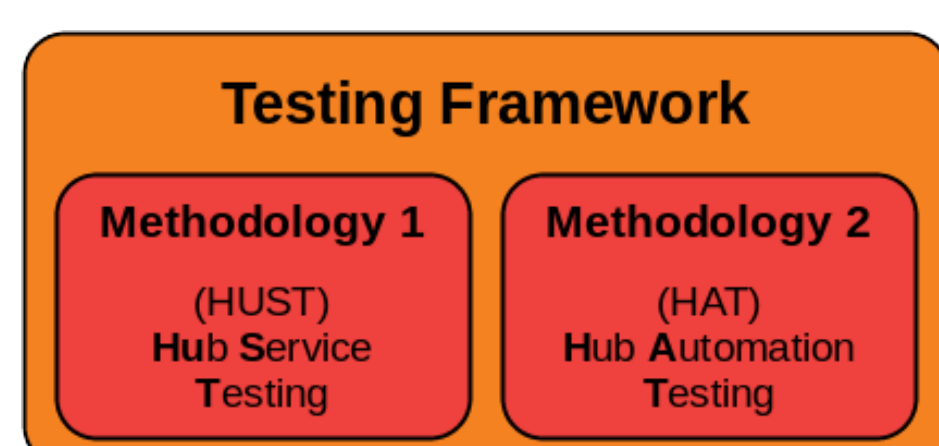


Figure 1: Testing framework details

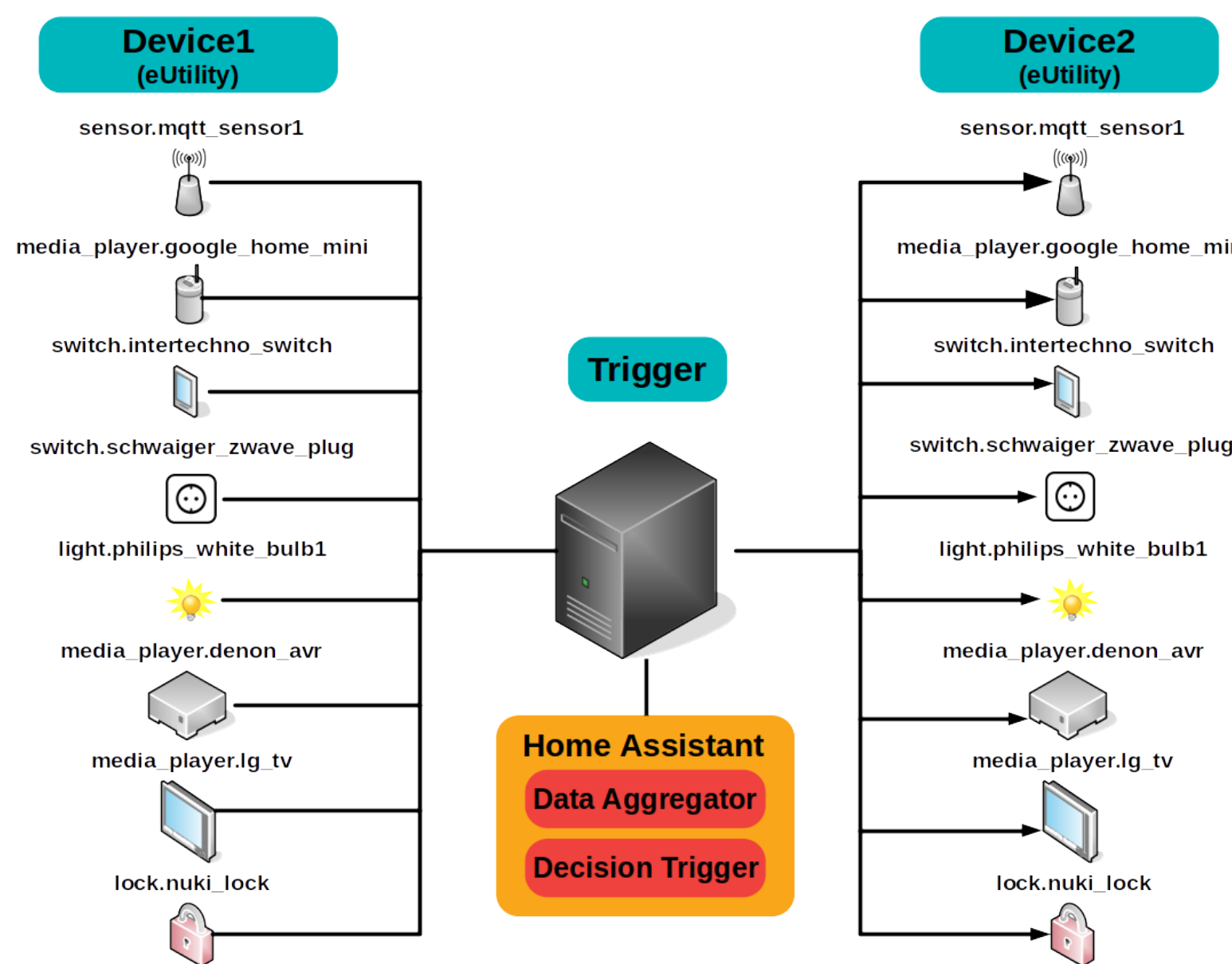
Testing Methodologies



- ▶ Analysis of the structure of some IoT home automation hub systems.
- ▶ Home Assistant, OpenHab, Domoticz, Samsung Smart, Things, Philips Hue Hub.
- ▶ Developed two different test modelling methodologies, based on combinatorial modelling techniques.

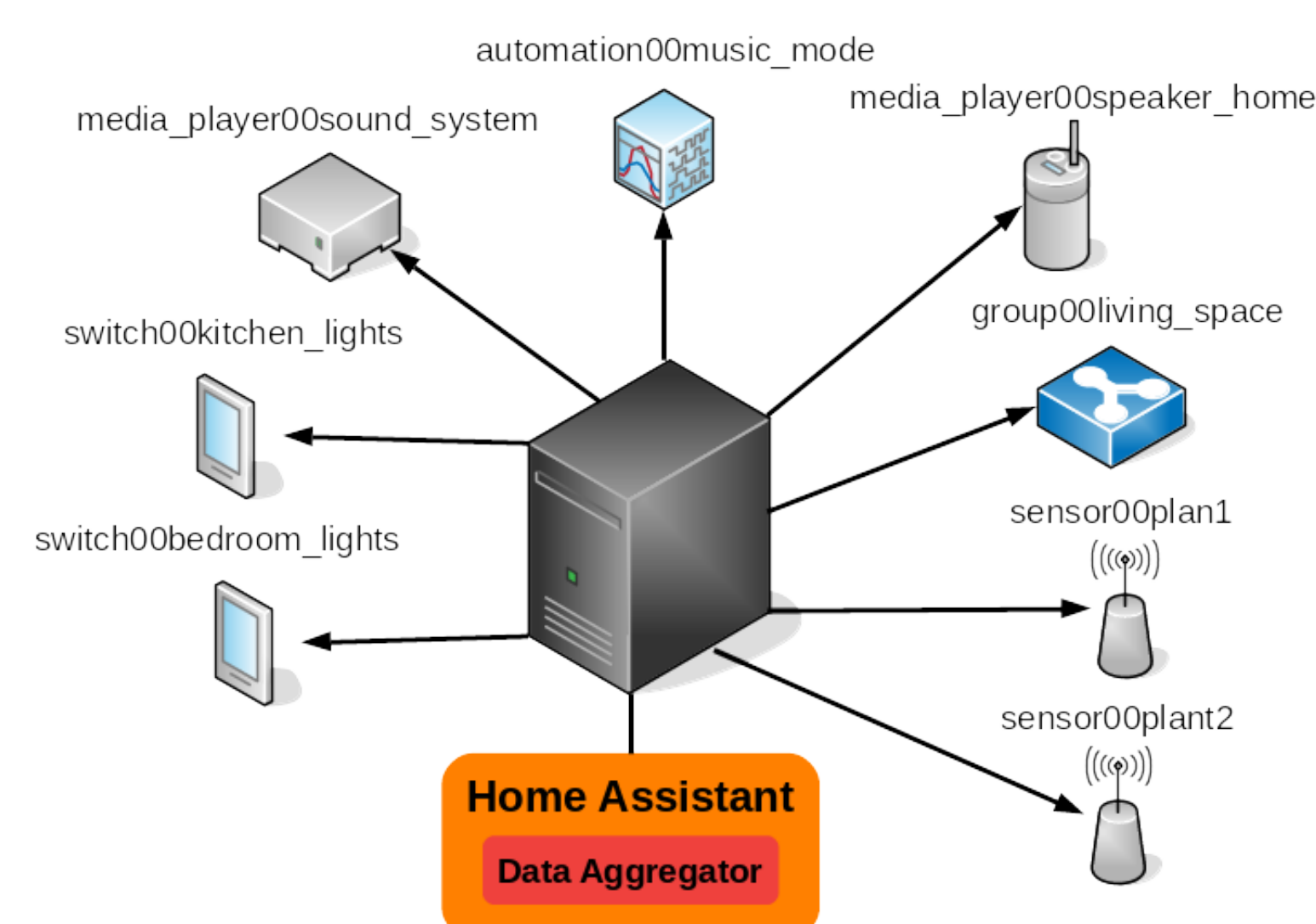
Hub Automations Testing (HAT) Methodology

- ▶ Targets the automation component of the hub.
- ▶ In Home Assistant mostly accessible by custom scripting.
- ▶ Automations can have three parts (trigger, condition, action).



HUB Services Testing (HUST) Methodology

- ▶ Global perspective on the hub
- ▶ Modelling all devices connected to the hub and their exposed functionality



Case Study

- ▶ Case study on one concrete IoT home automation hub (Home Assistant).
- ▶ HUST methodology with 8 devices, HAT with 18 devices.
- ▶ Errors grouped in categories for combinatorial analysis.
- ▶ Both methodologies were able to find a variety of different errors in the expected behaviour.

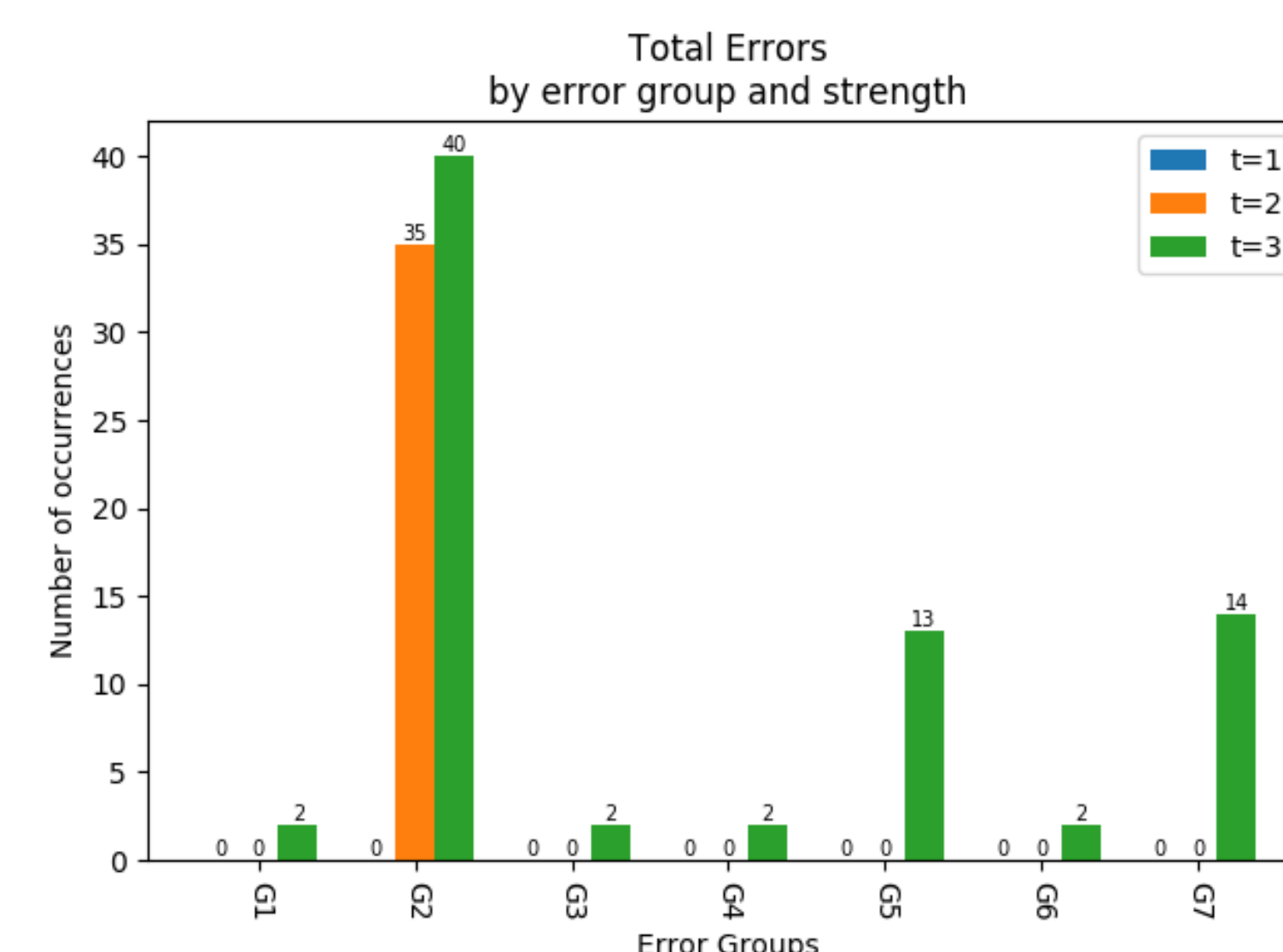


Figure 2: Results for all error groups of HAT methodology.

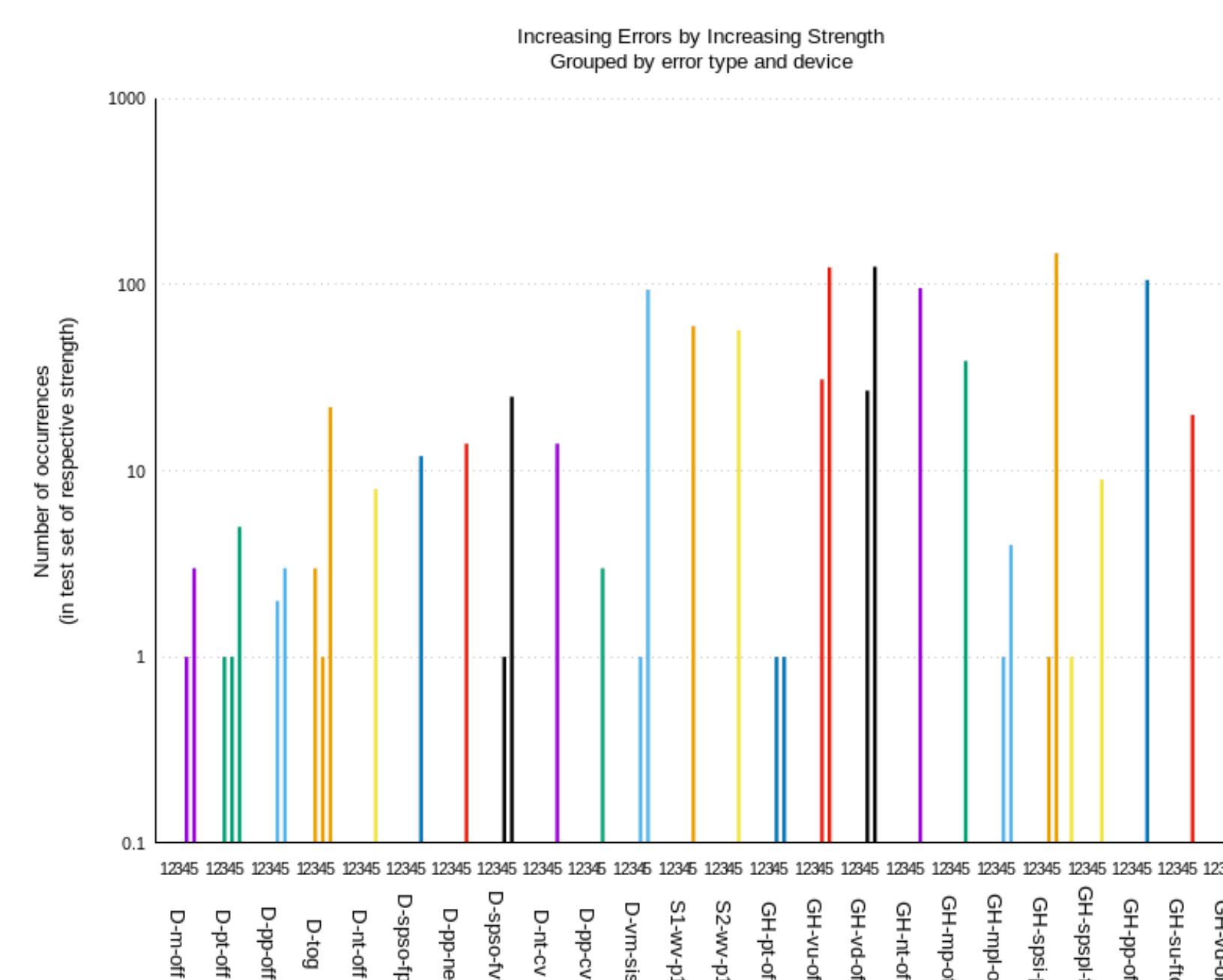


Figure 3: Results for all error groups of HUST methodology.

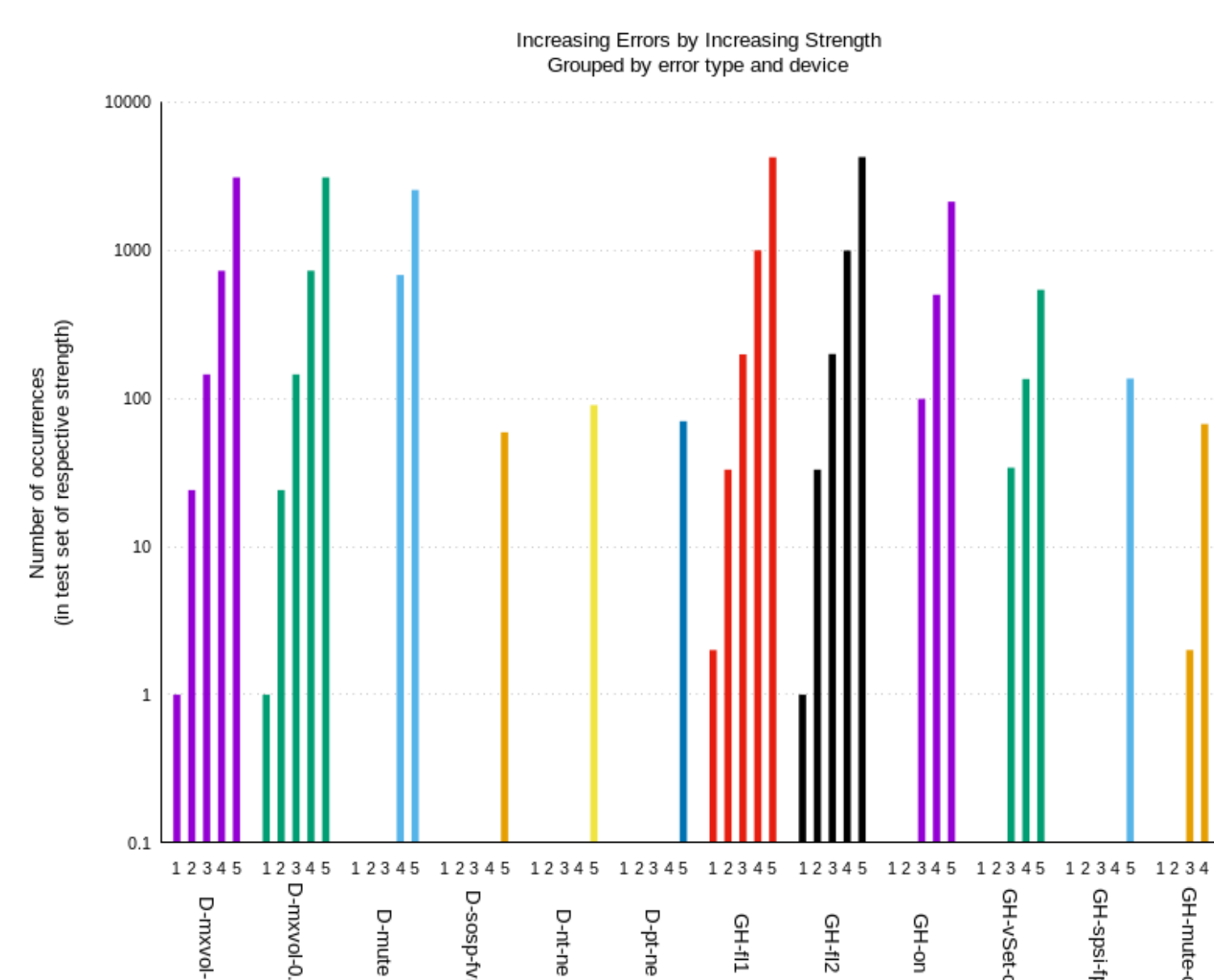


Figure 4: Results for all error groups of HUST methodology.