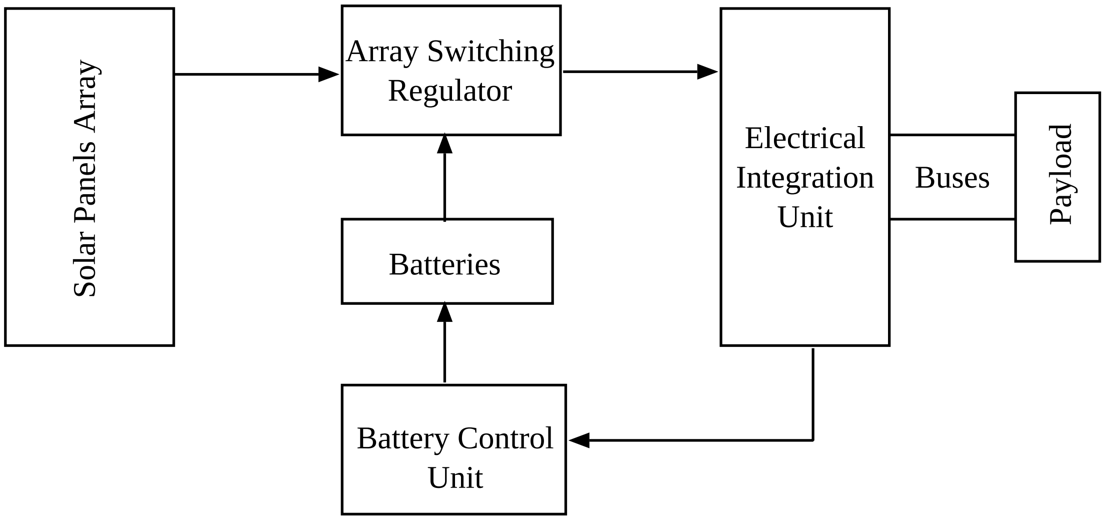
Temporal fault diagnosis

Using qualitative models to learn diagnostic rules was first demonstrated by Kardio [1]. The basic idea is simple. Use a qualitative model of a system to generate behaviours of the system. If there is a fault in the system, it will reflected in the behaviour generated by the model. This "faulty" behaviour can be used to provide examples for a learning program, which can then learn diagnostic rules for the particular fault. The resulting rules are thus guaranteed complete and correct for all single faults since all examples of these were generated from the original model. This technique is applicable to problems other than the original one considered in Kardio. An example is the power subsystem of a satellite. The basic structure of one such system is as follows



The arrows indicate the flow of supply. The qualitative model of this system consists of about 40 components and 29 sensors [3]. An important feature of this system is that the diagnosis of some faults are not possible with simple classification rules. These faults usually require the history of related components. For example, a simple check of power from the battery is not sufficient to determine if it is faulty. We need to know the history of other components in the circuit before this can be decided. Although many different faults can be simulated, the concern here is with battery faults. The information used is as follows:

- Examples are are recorded in time points. So, a positive example **fault(32).** states that there was a fault at time instance 32.
- Background knowledge records the status of the 29 sensors at each time point. The list of sensors is attached.
- During orbit, the basic operations of the power subsystem is divided into phases. The time instant that each phase commences is also provided as background knowledge.

- The succession of time instants is represented by the predicate **succ/2**.

The sensors in the power subsystem are as follows

tm040_switch: system switch status indicator.
tm018_switch: system switch status indicator.
tm031_switch: system switch status indicator.
m038_switch: system switch status indicator.
tm022_switch: system switch status indicator.
tm043_switch: system switch status indicator.
tm013_switch: system switch status indicator.
tm042_switch: system switch status indicator.
tm007_switch: system switch status indicator.
tm222_charging: battery charging status indicator.
tm071_asr_or_switch_20: system switch status indicator.
tm070_supply_3c: power supply from solar.
tm058_asr_or_switch_10: system switch status indicator.
tm057_supply_2c: power supply from solar.
tm257_battery_voltage: system battery status indicator.
tm017_switch: system switch status indicator.
tm009_switch: system switch status indicator.
tm220_supply_1c: power supply from solar.
tm055_supply_1b: power supply from solar.
tm054_supply_1a: power supply from solar.
tm029_ovt_disabled: battery over-temperature blocking signal.
tm021_eoc_disabled: battery end-of-charging indicator.
tm004_eoc_signaled: battery end-of-charging blocking signal.
tm002_battov_temp: battery over-temperature sensor.
tm039_eod_disabled: battery end-of-discharging blocking signal.
tm015_eod_signaled: battery end-of-discharging indicator.
tm011_eod_override : battery end-of-discharging overwriting signal.
tm001_eod_relay: battery end-of-discharging relay switch.
tm211_bus_voltage: system power bus status.

The dataset is stored as a compressed TAR file. Within that, the data files are as used in the original *Golem* [2] experiments. That is, background knowledge files have a ".b" suffix, positive example files have a ".f" suffix, and negative example files have a ".n" suffix.

References

[1] Bratko I., Mozetic I. and Lavrac N. (1989). *Kardio: a Study in Deep and Qualitative Knowledge for Expert Systems.* MIT Press, Cambridge Mass.

[2] Muggleton S.H. and Feng C. (1990). Efficient induction of logic programs. *Proceedings of the First Conference on Algorithmic Learning Theory*, Tokyo.

[3] Pearce D.A. (1988). The induction of fault diagnosis systems from qualitative models. *Proceedings Seventh National Conference on Artificial Intelligence*, Saint Paul, Minnesota.