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Outline of the framework

Heartbeat Channels: - PUB Lish your Islate every Nus - SUB saibe to everyone listens to transit and - proadrast state via heartbeat listen to heartbeat hig their importa Steady states & transitional dates

network of satellites that have a state and listen to commands

listeners that are passive components that can appear and disappear as they like

last part is a controller that has no state = not a satellite

but is something that can disconnect and reconnect

its the only component that can send commands to the satellites (e.g. a user interface)

question: what happens if we have a problem, e.g. network outrage, satellite goes down, ...

for this we came up with heartbeat system

HEARTBAT HEARTBAT HEARTBAT - has no state - has no state - sends transit cond - can go offine - only controller Can reset safe state - distributes configuration - importance (ist

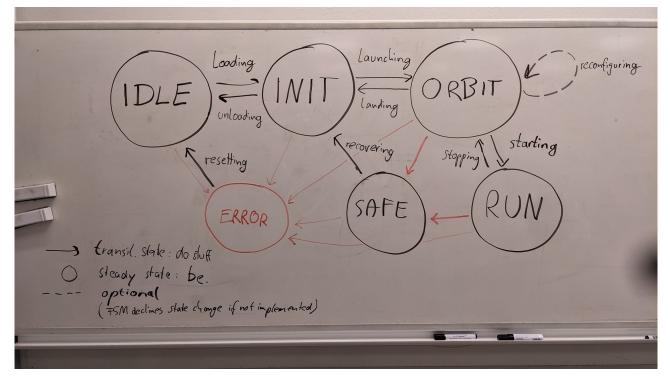
when the controller distributes setup information, all controllers are told which componentes they need to care about

if one goes into error state or its heartbeat stops, the satellite goes into a safe state

the heartbeat channel is also useful because after reconnecting the controller it will know about the state of the entire network after one heartbeat cycle

so the system is not autonomous, but on their own each component can go into a safe state when another has a problem

Satellite states



a satellite is started in idle, the controller can initiate state transiions

regular order of things idle-init-orbit-run and back

extra steps: reconfiguring (e.g. change a voltage) without going all the way down to init --> fast way to do scans

dashed line = optional, i.e. programmer of a satellite can chose to implement this or not

other special states: error state. only resetable to idle by manual intervention of user (reset the error after fixing the problem - might be something in software, could also be a hardware interlock switch if implemented by user).

when the other satellites in orbit or run state detect this, they go to safe state

Communication channels

A) Controlling

command request: consist of multiple parts

- 1) command , e.g. "load"
- 2) header (time, sender)
- 3) optional parameters, e.g. config options and parameter values for a configure commands

CMD: REQ Acknowledgen SUCCESS: Command WVALID: - Etime: 3 (header) [- E... 3] (payload, optional) NOTIMPLEME CMD: REP - acknowledgement [SUCCESS, INVALID, NCOMPLETE - Etime: NOTIMPLEM, WCOMPLETE Sender: 3 (Leader) - Etime: 3 (Leader) - Etime: 3 (Leader) - Etime: 3 (Leader)

reply

- 1) one of a number of possible acknowledgments (see below)
- 2) header (time, sender)
- 3) optional payload in return

Acknowledgements. SUCCESS: Command could successfully executed INVALID: command is not a valid transition out of the current state, e.g. - entirely unknown commands - commands belonging to other steady states [salling "start" from "INIT") d, optional) NOT IMPLEMENTED: optional transitions which have no implementation in this FSM (schellife (e.g. reconfigure) INCOMPLETE: valid command for current state, but mandatory , INVALID, U., WCOMPLETE information in payload is missing (e.g. , Loundh" with no configuration or "start" with no run identifier) optional)

B) Logging

DIWES Var

two other channels, work similar

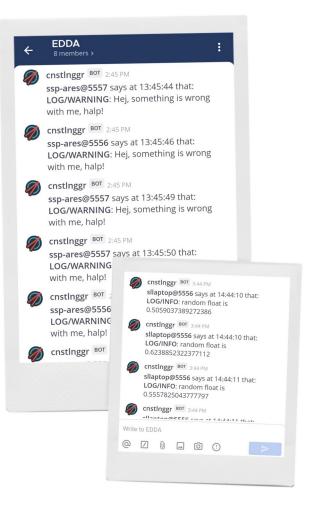
1. monitoring channel , e.g. trigger rates, temperatures – auxiliary information that helps the user monitor the state of the system contains first an idenfitication

then a header – time, sender, type of data to follow

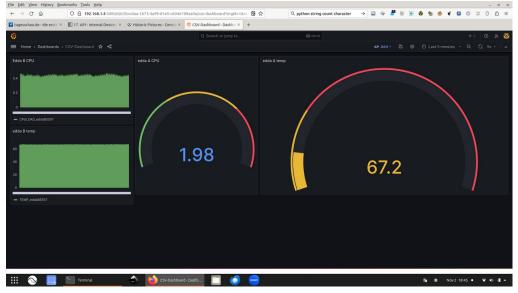
2. log channel, that contains a log level (e.g. trace, debug, info, warning, error, status) also a header, then a log message

the listeners can chose which topic to subscribe to ("LOG/DEBUG", "STAT/TEMP) only messages which have a subscriber will be distributed over the network

example implementations: mattermost logger that collects log messages and sends them to the network



Other example: first hacky implementation: python code to read stat of raspberry cpu temp and publish on a grafana dashboard



C) Data:

always a pipeline, ie point-to—point connection satellite that delivers data, another satellite that writes it to disk

very fast transfer for message blocks >1kb (just for very small data blocks the network overhead takes over)

D) Heartbeating

two classes

a) a thread that every second broadcasts the state of the satellites

b) a heartbeat checker that listens to other's heartbeats

Tested implementation

once you go into orbit state, you listen to the heartbeats of the other satellites screenshot example:

once one of them is gone or failure triggered, the other two go into safe state

python satellite.py ~/s/constellation-tests				and attend over to	diamond have	Q) = ×	
python satemice.py */s/constellation-tests		Ð		n sub_client_mu ~/s/				
		File "/home/si	imonspa/software	constellation/	-tests/logsandb	ox/sub_clier	nt_multim	
o/constellation-tests main python satellite.py	× INT 198 425	sage.py", line	e 81, in run t(self.poller.po	11(1)				
by construction terta mouth python satercite.py	A 101 191 425	SOCKS = dict	imonspa/.local/l	th (nythen2 10/	eite-nackages/7	na/sugar/nol	11.04". 1	
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png		return zmg r	poll(self.socket	s. timeout=tim	eout)			
-11-02 11:13:07,339 INFOmain: Satellite listeni	ng on command port 2399	File "zmg/back	kend/cython/_pol	.pyx", line 1	21, in zmg.back	end.cython.	poll.zmg	4
		oll						
-11-02 11:16:15,231 INFO root: Satellite Initialized			kend/cython/chec	krc.pxd", line	13, in zmq.bac	kend.cython.	checkrc.	
-11-02 11:16:52,443 INFO root: Registered heartbeati		heck_rc						
51235	Ke	yboardInterrup	pt .					
-11-02 11:16:57,456 INFO root: Registered heartbeati 61234	ng check for 192.168.1.							
51234 -11-02 11:18:07,322 INFO root: started hb thread		/so/constellat	tion-tests/logsa 113:5555pub 1		python <u>sub_clie</u>	/TNEO	sage py -	
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-11-02 11:18:07,323 INFO root: Thread 0 starting hea		nnecting to 19	2.168.1.113:555	5				
-11-02 11:18:07,324 INFO root: Thread 1 starting hea			topics ['LOG/INF					
-11-02 11:18:31,565 ERROR root: There is a failure.	Co	nnecting to 19	2.168.1.113:555	5				
			topics ['LOG/INF					
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yboardInterrupt:						-		
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CHIRP protocol

for network discovery – don't want to have to enter all IPs and ports by hand when setting up a measurement environment

when a satellite o.ä starts it will send a message offering up what it is and what services it offers

If a satellite starts later, it can send a request, e.g. for a logging service, and all logging services on the network that offer this service will reply again

https://gitlab.cern.ch/constellation/constellation/-/blob/master/docs/protocols/chirp.md

Config files:

Two example ideas (toml, yaml) Need to establish a way that the config is provided to the satellites then the rest can also be opened to user implementations

```
🗧 example.yaml 🚦 1.16 KiB
       1
          # This is a collection of ideas how a config file could look like in YAML
          mvConstellation:
            satellites:
              eddaA:
       5
                threshold: 123
       6
                system:
                  importance: essential
       7
       8
       9
             eddaB:
       10
                # parameters are the ones for the specific satellite
       11
               compliance: .105
               voltage: 50
       13
                # system section defines behavior in constellation
              system:
       14
                 # system parameters throw error for "additional" params, e.g. one with a typo importance: essential
       15
       16
                start_after: eddaA
       17
                                                  🔅 example.toml 🖞 756 B
       18
      19
             eddaTemp:
                                                          1 # This is a collection of ideas how a config file could look like in TOML
       20
                refresh_rate: 1
               refresh_rate: 1
calib_file: "/data/eddaTemp/2023
                                                          2 [Constellation]
      21
                                                          3 name = "myConstellation"
      22
               system:
                                                          4
      23
                  importance: optional
                                                          5 [eddaA]
                                                          6 importance = "essential"
      24
      25
             storageA:
                                                          7
      26
                file_pattern: "edda_a_run_%i.bin
                                                          8 [eddaB]
      27
               receive: eddaA
                                                          9 voltage = 50
      28
                                                         10 compliance = .105
                                                         11 [eddaB.system]
12 importance = "essential"
      29
             storageB:
                file_pattern: "edda_b_run_%i.bin
      30
                                                          13 start_after = "eddaA"
      31
                receive: eddaB
                                                          14
                                                          15 [eddaTemp]
                                                          16 refresh_rate = 1
                                                          17 calib_file = "/data/eddaTemp/20231102/my_calib_file.csv"
                                                          18 [eddaB.Temp]
                                                          19 importance = "optional"
                                                          20
                                                          21 [storageA]
                                                          22
                                                             file_pattern = "edda_a_run_%i.bin"
                                                          23 receive = "eddaA"
                                                          24
                                                          25 [storageB]
                                                          26 file_pattern = "edda_b_run_%i.bin"
                                                          27 receive = "eddaB"
                                                          28
                                                          29 [alarm]
                                                          30 mattermost_url = "https://mattermost.web.cern.ch/key/hufw87cw4fgc"
                                                          31 alarm_level = "WARNING"
```