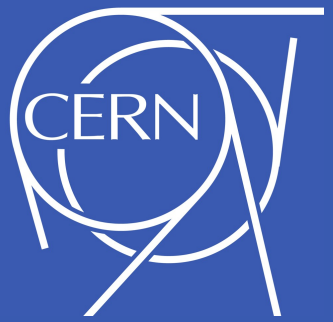
Bringing the power of dynamic languages to hardware control systems

J. M. Caicedo, R. Stoica, N. Neufeld

CERN, European Organization for Nuclear Research



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Problems

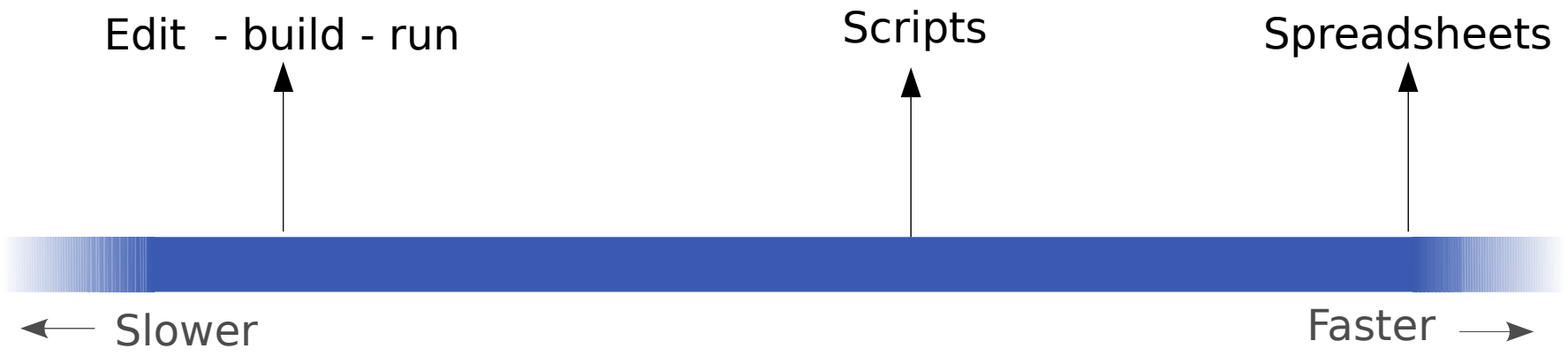
- Integrating new devices into a DCS can be complicated
  - Learn how the device works
  - Different protocols for communicating with the devices
  - Requires prototyping and experimentation

Problems

- Software developed and maintained by people from multiple backgrounds
- Traditionally DCS use system languages
  - Complexity
- Not written in isolation: frameworks, build environments ...

Problems

- The development cycle depends on the ease of doing changes.



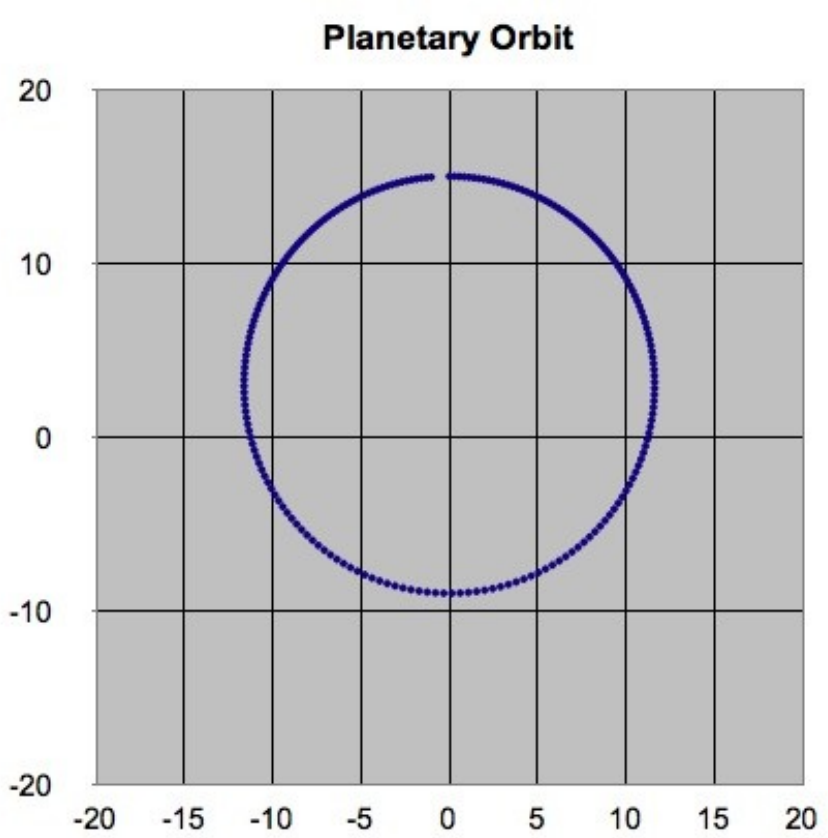
If only it could be this easy ...

Planet.numbers

Arial | Negrita | 10 | Ajustar | Fino

Hojas | 20

	A	B	C	D	E	F	G
1	**Planetary Motion**				*Michael Fowler, UVa*		
2							
3	***Leapfrog Integration***						
4							
5							
6	G=	20		To get an undistorted picture of the orbit,			
7	delta t=	0.28		turn off automatic scaling, click on the chart			
8	x init=	0		area and stretch it appropriately so that			
9	y_init=	15		one unit in the x-direction on your chart			
10	v x init=	1		looks the same length as one unit in the			
11	v y init=	0		y-direction. To print, in Print Preview turn off			
12				Scale to Fit Page			
13				halfway variables			
14	time	x	y	v_x	v_y	a_x	a_y
15	0	0	15	1	-0.012444	0	-0.088889
16	0.28	0.28	14.996516	0.9995353	-0.037332	-0.00166	-0.088884
17	0.56	0.5598699	14.986063	0.9986057	-0.062215	-0.00332	-0.088868
18	0.84	0.8394795	14.968642	0.9972106	-0.087091	-0.004982	-0.088842
19	1.12	1.1186985	14.944257	0.9953492	-0.111956	-0.006648	-0.088806
20	1.4	1.3973962	14.912909	0.9930205	-0.136809	-0.008317	-0.088759
21	1.68	1.675442	14.874603	0.990223	-0.161645	-0.009991	-0.088701
22	1.96	1.9527044	14.829342	0.9869551	-0.186462	-0.011671	-0.088631
23	2.24	2.2290518	14.777133	0.9832151	-0.211256	-0.013357	-0.088551
24	2.52	2.5043521	14.717981	0.9790006	-0.236024	-0.015052	-0.088459
25	2.8	2.7784722	14.651894	0.9743092	-0.260764	-0.016755	-0.088354
26	3.08	3.0512788	14.578881	0.9691383	-0.28547	-0.018468	-0.088237
27	3.36	3.3226375	14.498949	0.9634848	-0.31014	-0.020191	-0.088108
28	3.64	3.5924132	14.41211	0.9573454	-0.33477	-0.021926	-0.087964
29	3.92	3.8604699	14.318374	0.9507166	-0.359356	-0.023674	-0.087807
30	4.2	4.1266706	14.217754	0.9435946	-0.383894	-0.025436	-0.087635
31	4.48	4.3908771	14.110264	0.9359751	-0.408379	-0.027212	-0.087448
32	4.76	4.6529501	13.995918	0.9278539	-0.432808	-0.029004	-0.087244
33	5.04	4.9127492	13.874732	0.9192262	-0.457174	-0.030813	-0.087024
34	5.32	5.1701326	13.746723	0.9100871	-0.481474	-0.03264	-0.086785
35	5.6	5.424957	13.61191	0.9004312	-0.505702	-0.034485	-0.086528
36	5.88	5.6770777	13.470313	0.890253	-0.529852	-0.036351	-0.086251
37	6.16	5.9263485	13.321955	0.8795466	-0.55392	-0.038237	-0.085954
38	6.44	6.1726216	13.166857	0.8683059	-0.577897	-0.040145	-0.085634
39	6.72	6.4157472	13.005046	0.8565245	-0.601779	-0.042077	-0.085291
40	7	6.6555741	12.836548	0.8441956	-0.625557	-0.044032	-0.084924



Estilos

suma | med | mín | máx | contar

100%

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15	0	0	15	1	-0.024889	0	-0.177778
16	0.28	0.28	14.993031	0.99907	-0.074687	-0.003321	-0.17785
17	0.56	0.5597396	14.972119	0.997206	-0.124546	-0.006657	-0.178067
18	0.84	0.8389573	14.937246	0.9944	-0.174506	-0.010022	-0.17843
19	1.12	1.1173893	14.888384	0.9906397	-0.224609	-0.01343	-0.178939
20	1.4	1.3947684	14.825494	0.9859087	-0.274896	-0.016896	-0.179598
21	1.68	1.6708228	14.748523	0.9801861	-0.325411	-0.020438	-0.180408
22	1.96	1.9452749	14.657408	0.9734462	-0.376195	-0.024071	-0.181372
23	2.24	2.2178398	14.552073	0.9656584	-0.427294	-0.027814	-0.182495
24	2.52	2.4882242	14.432431	0.9567866	-0.478752	-0.031685	-0.183781
25	2.8	2.7561244	14.29838	0.9467892	-0.530618	-0.035705	-0.185234
26	3.08	3.0212254	14.149807	0.9356178	-0.582939	-0.039898	-0.18686
27	3.36	3.2831984	13.986585	0.9232173	-0.635765	-0.044287	-0.188666
28	3.64	3.5416992	13.80857	0.9095249	-0.68915	-0.048901	-0.190659
29	3.92	3.7963662	13.615608	0.8944692	-0.743147	-0.05377	-0.192847
30	4.2	4.0468176	13.407527	0.877969	-0.797814	-0.058929	-0.195238
31	4.48	4.2926489	13.18414	0.8599327	-0.853209	-0.064416	-0.197842
32	4.76	4.53343	12.945241	0.8402559	-0.909396	-0.070274	-0.200668
33	5.04	4.7687017	12.69061	0.8188207	-0.96644	-0.076554	-0.203729
34	5.32	4.9979715	12.420007	0.7954929	-1.02441	-0.083313	-0.207035
35	5.6	5.2207095	12.133172	0.7701202	-1.083378	-0.090617	-0.210598
36	5.88	5.4363431	11.829826	0.7425286	-1.143419	-0.098541	-0.214432
37	6.16	5.6442512	11.509669	0.7125198	-1.204612	-0.107174	-0.218548
38	6.44	5.8437567	11.172377	0.6798662	-1.267041	-0.11662	-0.22296
39	6.72	6.0341193	10.817606	0.6443062	-1.330791	-0.127	-0.227678
40	7	6.214525	10.444985	0.605538	-1.39595	-0.138458	-0.232711

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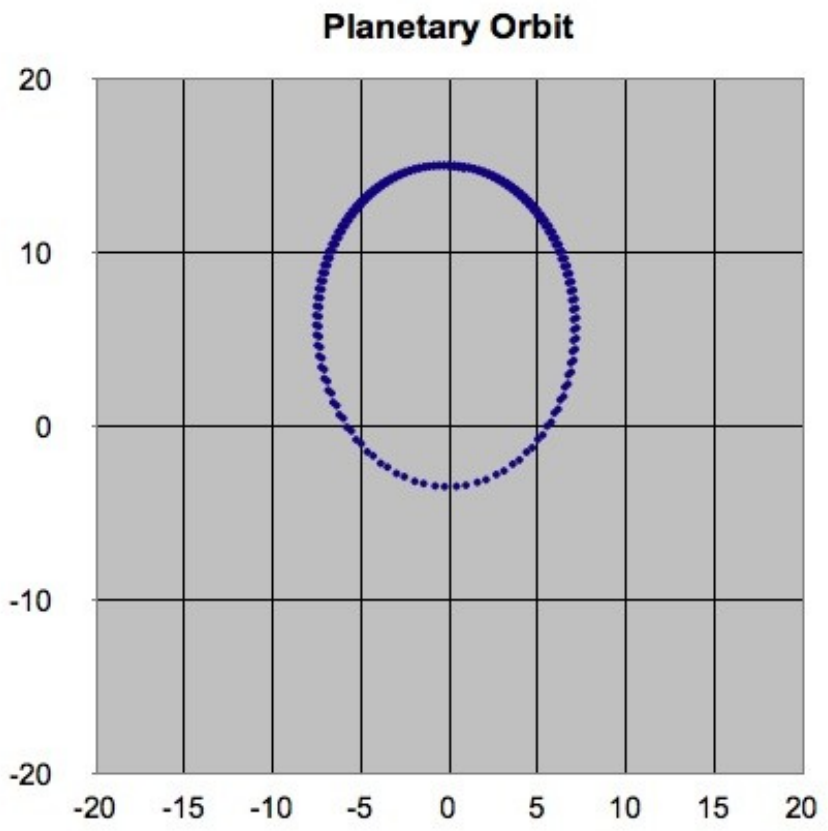

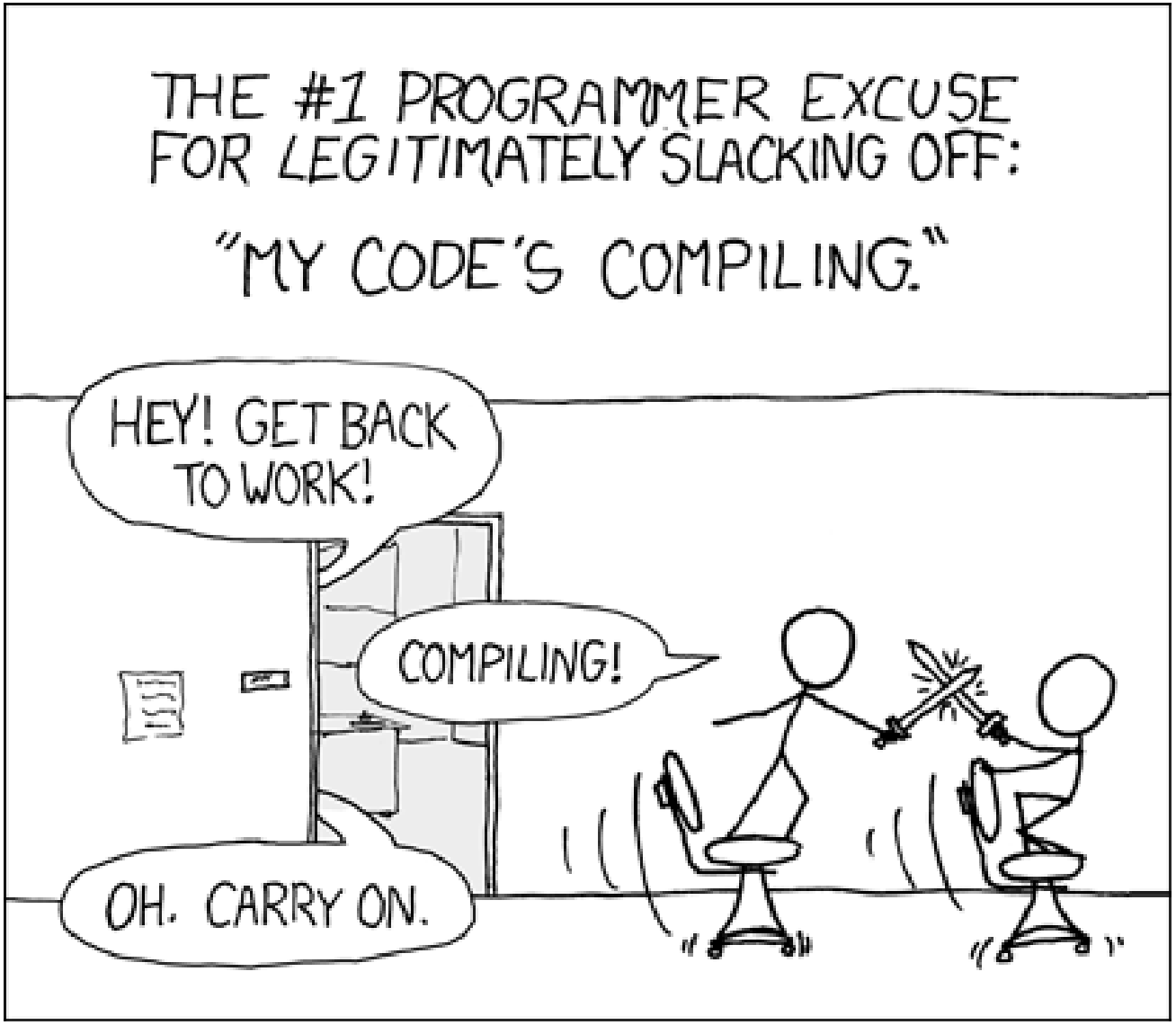
THE #1 PROGRAMMER EXCUSE FOR LEGITIMATELY SLACKING OFF:
"MY CODE'S COMPILING."
HEY! GET BACK TO WORK!
COMPILING!
OH. CARRY ON.

Our approach

- To use dynamic languages for controlling devices
- Integration with the LHCb ECS

Dynamic languages

- Interpreted
- Reflection
  - Modify the program at run time
- Higher level instructions and data types
  - Less verbose
  - Example: string manipulation

Interactive programming

- Receive immediate feedback
- Fast *edit – test – debug* cycle
- Encourages prototyping

Productivity

- **Warning!** Qualitative and anecdotal evidence
- Higher level instructions
- Useful data structures
- “Do more with less code”

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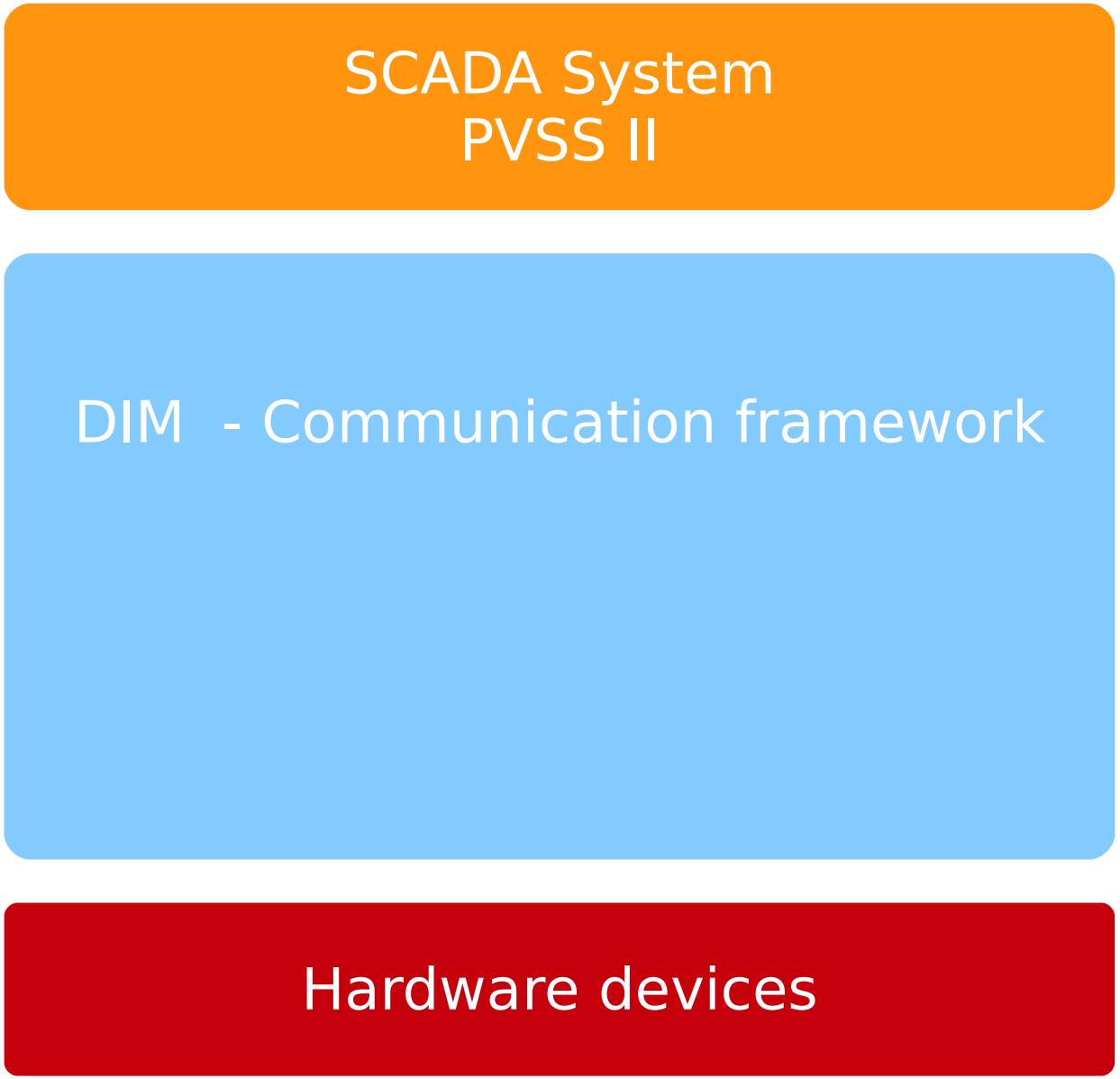
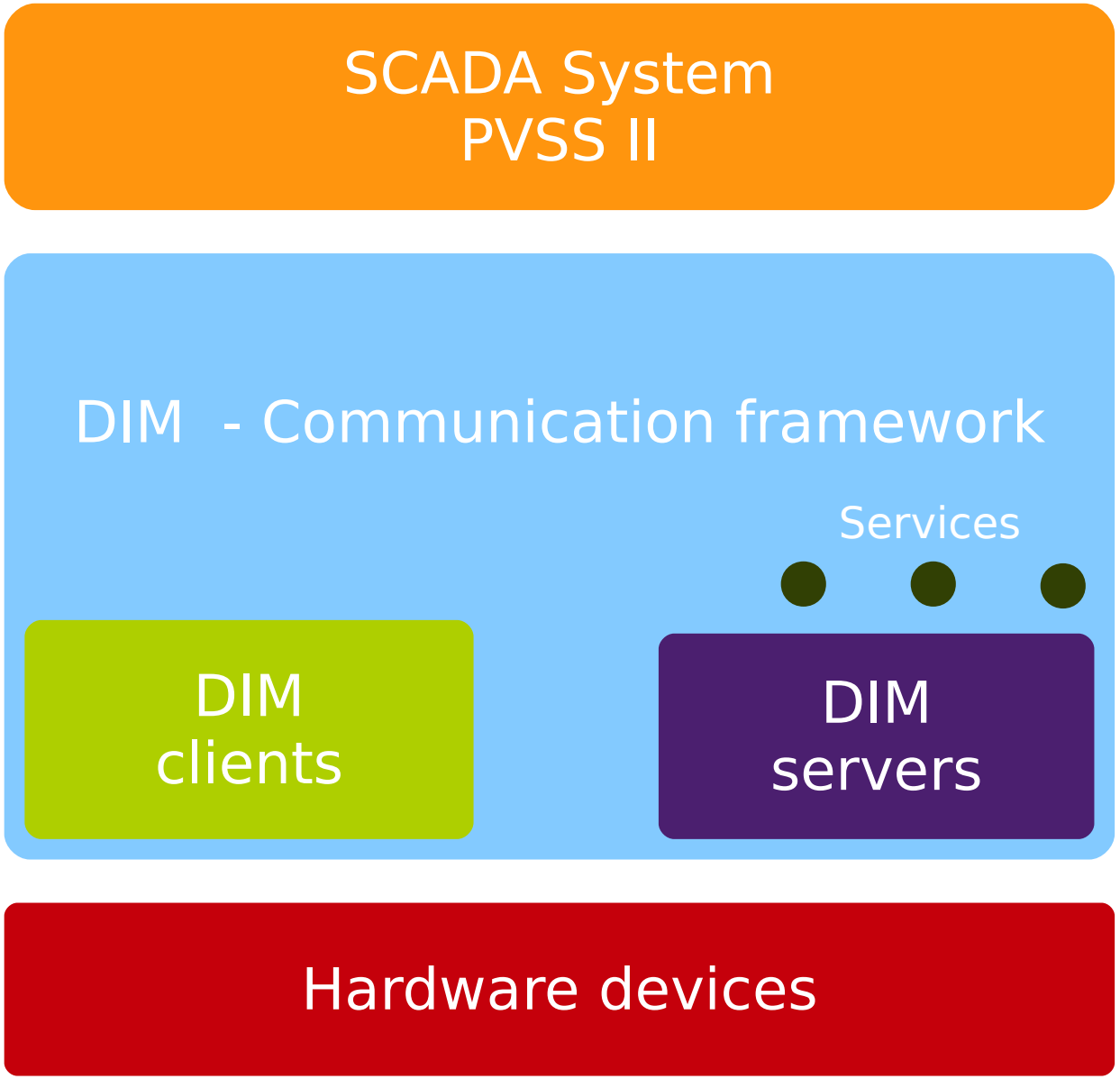
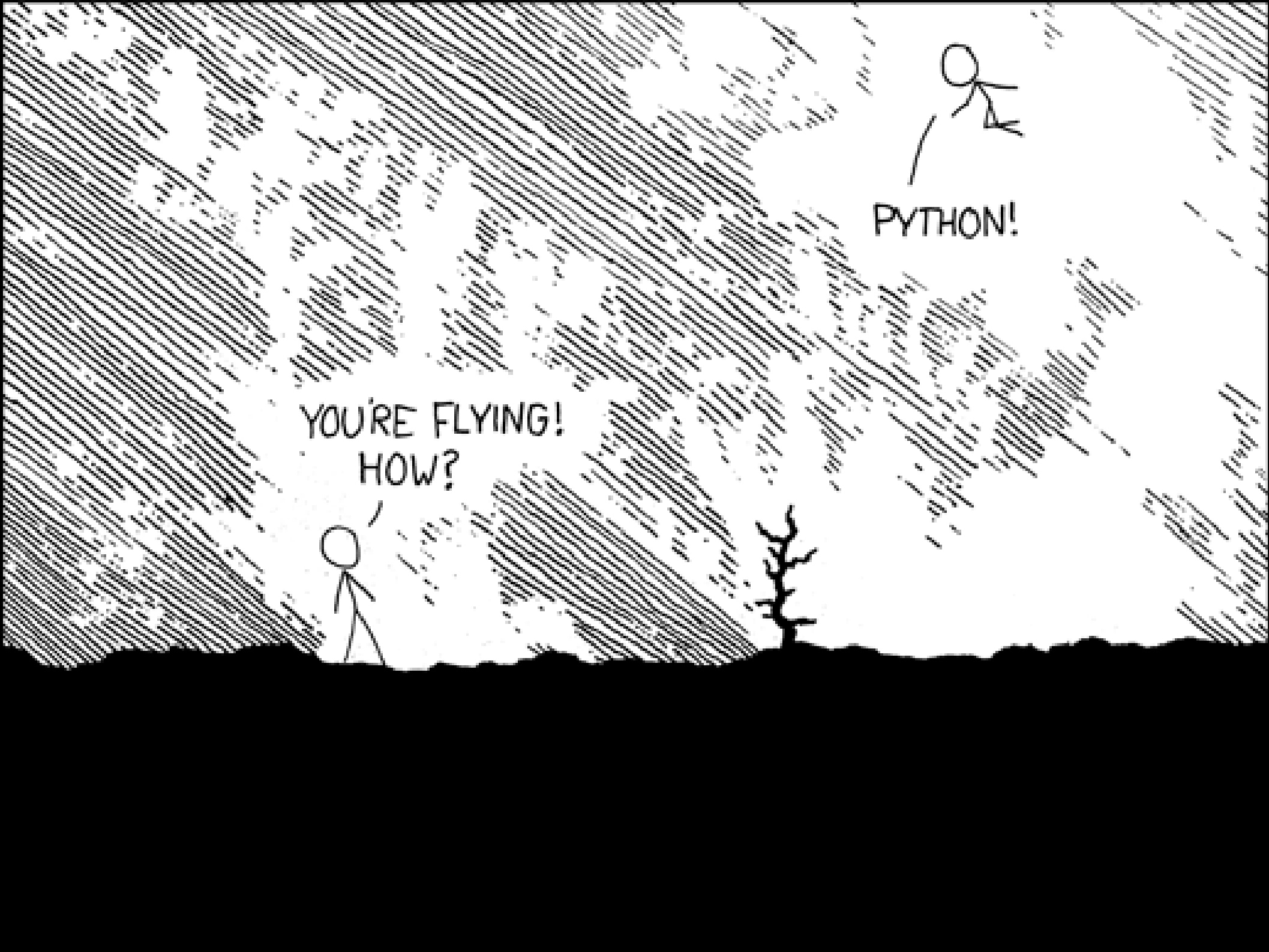

SCADA System
PVSS II
DIM - Communication framework
Hardware devices


SCADA System
PVSS II
DIM - Communication framework
Services
DIM
clients
DIM
servers
Hardware devices


PYTHON!
YOU'RE FLYING! HOW?

PyDIM = Python + DIM

- Wrapper around DIM C library
- Write DIM clients and servers in Python
- Transparent conversion of data types
- Compatible with other DIM clients and servers
- All the DIM features are available

Performance: PyDIM vs C/C++

Is it slow? Yes.

	PyDIM	C/C++
Latency	1980 µs	996 µs
Memory usage	2416 kB	472 kB
Throughput	249 k serv/s	563 k serv/s

Maximum memory used for a DIM server with 25 services

Average throughput of a client receiving messages of different sizes (4k - 512k)

Example

Control power management devices

Powersocket

- Integrate the devices interface with the ECS
  - Telnet: pexpect module
  - SNMP
- Enable communication via DIM
- Prototype different alternatives

Conclusions

- Dynamic languages can provide a shorter development cycle
- PyDIM and DIM: enable efficient and reliable communication
- Dynamic languages features have a performance cost
  - Implementation techniques