

A ReSTful Interface for CubeSats

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CubeSat Developers' Workshop
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CubeSat Software Interfaces

- Many mission unique protocols
- Low level manipulation
- Protocol libraries
- Platform lock
- Interface documents
- Etc...

```
#include <stdio.h>
#define m 21
#define o(l, k) for(l=0; l<k; l++)
#define n(k) o(T, k)

int E,L,O,R,G[42][m],h[2][42][m],g[3][8],c
[42][42][2],f[42]; char d[42]; void v( int
b,int a,int j){ printf("\33[%d;%df\33[4m"
"m ",a,b,j); } void u(){ int T,e; n(42)o
(e,m)if(h[0][T][e]-h[1][T][e]){ v(e+4,e,T+2
,h[0][T][e]+17h[0][T][e]:0); h[1][T][e]=h[
0][T][e]; } fflush(stdout); } void q(int l
,int k,int p){
int T,e,a; L=0
; O=1; while(0
){ n(4&&L){ e=
k+c[l][T][0];
h[0][L-1+c[l][
T][1]][p?20-e:
e]=-1; } n(4){
l)+1; if(a==42
; } } n(4){ e=
T][1]][p?20-e:
u()); } n(42) {
o(a, m&&e==m){
]=h[0][L-1][a
}int main(){ int T,e,t,r,i,s
l][T]=7-T; R--; n(42) o(e,m)
R; n(17){ e=d[T]-48; d[T]=0;
} } n(8)if(g[0][7-T]){ t=g[i
g[2][g[i][T]]=T; n(R+i)o(e,m
)o(t,2){ f[T+t+T]=(T["+&#x4
[e][t]="5'<=$8)Ih$=h9i8'9"
} } n(15) { s=T>97m:(T&3)-3?15:36;o(e,s)o(t,2)c[T+19][e][t]="6*6,8*6.608.6264826668\
865::(+:0(6+6-6/8.61638065678469.:88)) ( )3(6.8*6.608.6264826668865:+:4)-#6-6/616365.\
|e=k+c[l][T][0]; a=L+c[l][T][
|| h[0][a][p?20-e:e+1]){ O=0
k+c[l][T][0]; h[0][L + c[l][
e]=g[1][f[p?19+l:l]]; } L++;
o(e,m)if(h[0][T][e]<0)break;
for(L=T; L; L--) { h[0][L][a
]; } h[0][0][a]=-1; } } u();
,D,V,K; printf("\33[2J\33[725l"); n(8)g[i=
G[T][e]--; while(fgets(d,42,stdin)) { r++
if ((e&7)==e) { g[0][e] ++; G[R][T+2]=e; }
][0]; g[i][0++]=g[i][T]; g[i][T]=t; } n(8)
)if(G[T][e]+i) G[T][e]=g[2][G[T][e]]; n(19
"5>GP9$5-,#C7NX"-35)>>t+3&7; o(e,4){ c[T]
"t)=83)l4(99(g9>#&#4(" [T+t+T]-35)>>e+2&3;
```



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Software Interfaces Ideally..

- Universal
- Language independent
- Platform independent
- High Level
- Able to leverage open source code
- Simple to document

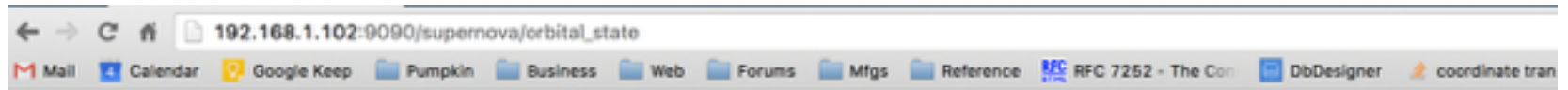
- Where would we find something like that?

ReST - “The software architectural style of the Web”¹

- Representational State Transfer
- ReSTful system constraints:
 1. Client-Server
 2. Stateless
 3. Cache
 4. Uniform Interface
 5. Layered
 6. Code on Demand
- Protocol + Data Format not explicitly stated
 - But *HTTP* + *JSON* are web standard

What does using ReST look like?

- Browser demo



```
{  
  "eci_dx_kms": 2.4453357689384707,  
  "eci_dy_kms": -5.236508654841261,  
  "eci_dz_kms": -5.032283151039424,  
  "eci_x_km": -6129.230374071741,  
  "eci_y_km": -69.38074892405864,  
  "eci_z_km": -2911.6373186760843,  
  "timestamp": "2016-04-21T22:16:54.104683"  
}
```

Payload Example - Python

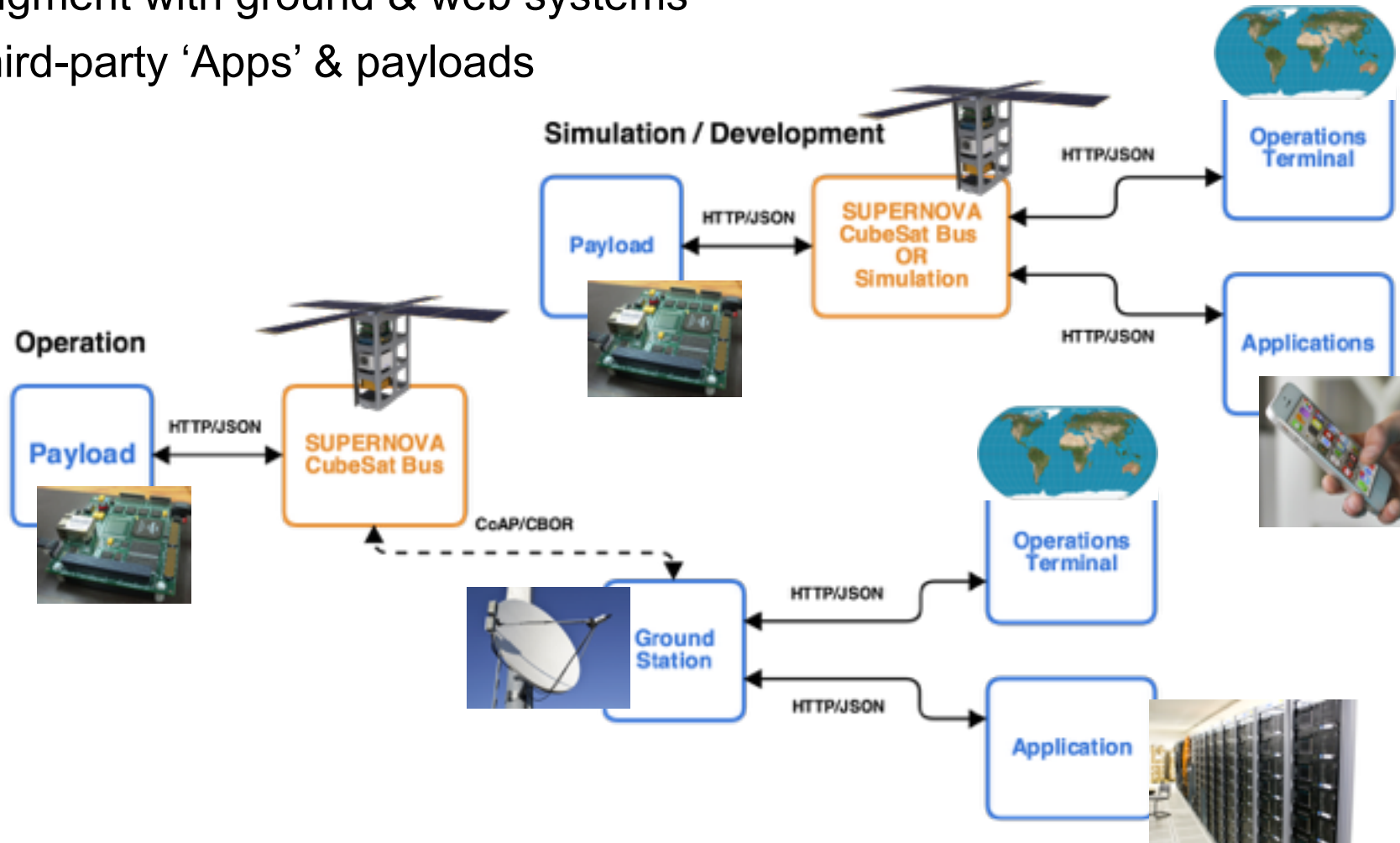
```
1 import urllib, json
2 conn = urllib.HTTPConnection("192.168.1.101")
3 conn.request("GET", "/datasets/orbital_state") # --- Requesting
4 response = conn.getresponse()
5 if response.status == 200 # --- Error Checking
6     data = json.loads(response.read()) # --- Parsing
7     print data['eci_x_km'] # --- Printing
8
```

Payload Example - JavaScript

```
1 var request = new XMLHttpRequest();
2 request.open("GET", "http://192.168.1.101/datasets/orbital_state", true);
3 request.send(null); // Requesting
4 if (request.status == 200) { // Error Checking
5     data = JSON.parse(conn.responseText); // Parsing
6     document.write(data.eci_x_km); // Printing
7 }
8 |
```


ReST/HTTP Extensibility

- Augment with ground & web systems
- Third-party 'Apps' & payloads



ReST Implementation - Hardware

- **SUPERNOVA Bus**
 - 64W Solar Power
 - Ethernet Switch (in development)
 - Up to 4U Payload Volume
- **BeagleboneBlack Flight Computer**
 - ~2W
 - 1GHz ARM CPU
 - Linux



ReST Implementation - Software

- **Augments high-TRL bus flight software**
 - Low-level interface still available
- **“API First”**
 - Describe interface with using “Swagger.io” standard & tools
 - ◆ <http://www.swagger.io>
 - Auto-generate documentation from spec
 - Auto-generate HTTP server stubs from spec
 - Fill in the callbacks

Swagger Document Generation

```
File - Preferences - Generate Server - Generate Client - Help -
8 info:
9 title: SUPERNOVA REST API
10 description:
11 Specifies the HTTP API for the SUPERNOVA EU CubeSat bus.
12 version: '0.1.2'
13 contact:
14 email: shaun@pumpkininc.com
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```

SUPERNOVA REST API

Specifies the HTTP API for the SUPERNOVA EU CubeSat bus.

Version 0.1.2

Contact information
shaun@pumpkininc.com

Filter operations by a tag:
status commands datasets files

Paths

/

GET / status

Description
Return SUPERNOVA bus identifying information

Responses

Code	Description	Schema
200	OK	<pre>info { spacecraft_id: string operator: string tie1: string tie2: string }</pre>

[Try this operation](#)

/system_time

GET /system_time status

Description
Return current system time and status in UTC ISO datetime

Responses

Code	Description	Schema
200	OK	<pre>system_time { utc_datetime: string sysc_status: string }</pre>

Payload Demo...

```
1  #!/usr/bin/python
2  import urllib, json, time, math
3  connection = urllib.HTTPConnection("192.168.2.101", port=9090, timeout=2)
4  while True:
5      try:
6          connection.connect()
7          connection.request("GET", "/supernova/orbital_state")
8          response = connection.getresponse()
9          if response.status == 200:
10             state = json.loads(response.read())
11
12             position = (state["eci_x_km"], state["eci_y_km"], state["eci_z_km"])
13             distance = math.sqrt(sum([math.pow(x, 2) for x in position]))
14             earth_rad = 6371
15
16             print "Position at " + state["timestamp"] + "\n" + position
17             print "Hello from " + str(distance - earth_rad) + " km!\n"
18
19         except:
20             print "No Connection"
21         time.sleep(4)
```

Conclusions + Future

- **ReST fits Pumpkin approach to Nanosats**
 - Open, Standardized, Accessible, Scalable, Modular, Customizable
 - “Fly Your Laptop”
- **Development at Pumpkin:**
 - HTTP payload interface to SUPERNOVA
 - SUPERNOVA Bus Simulator



Q&A Session

Thank you for attending this Pumpkin presentation at the 2016 CubeSat Developer's Workshop!

Appendix

- **Further Reading**

- https://www.ics.uci.edu/~fielding/pubs/dissertation/rest_arch_style.htm
- <http://whatisrest.com>
- <http://coap.technology>
- <http://cbor.io>
- <http://swagger.io>

- **Speaker information**

- Shaun Houlihan is an Engineer at Pumpkin involved in developing SUPERNOVA hardware and software. Before joining Pumpkin he worked in the aerospace and consumer electronics industries. Contact Shaun at shaun@pumpkininc.com.

- **CubeSat Kit information**

- More information on Pumpkin's CubeSat Kit can be found at <http://www.cubesatkit.com/>. Patented and Patents pending.

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www.pumpkininc.com/content/doc/press/20160420_Pumpkin_CSDWSLO_2016.pdf

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