



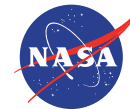
Bridging the Gap: Web-Based SLE Solution for an Existing MDOS

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AMMOS Mission Data Processing and Control System

- AMPCS is NASA Advanced Multi-Mission Operations System's (AMMOS) telecommanding, telemetry processing, and user display ground data system
- Users: MSL*, SMAP, InSight, MarCO, INSPIRE, SWOT, NISAR, Europa, and EM-1 CubeSat Missions
- A major product re-architecture project started in FY17 ("Release 8") and will include new interfaces and capabilities:
 - CCSDS Space Link Extension (SLE) Services
 - CCSDS File Delivery Protocol (CFDP)
 - Target Date: September 20, 2018
- AMMOS collaboration with Johns Hopkins University Applied Physics Laboratory (APL) started in 2015
 - Gained valuable SLE and CFDP domain knowledge and experience

* Using custom MPCS

SLE Needed Sooner

- Exploration Mission 1 (EM-1) CubeSat Missions
 - *Lunar Flashlight*
 - *Lunar IceCube*
 - *Lunar Polar Hydrogen Mapper (LunaH-Map)*
 - *Near-Earth Asteroid Scout (NEA Scout)*
 - Use NASA's Deep Space Network (DSN)
 - Launch Date: September 30, 2018
- Requirement: 'Use SLE'
- SLE capability needed to be delivered in Release 7 to achieve mission risk reduction needs

CCSDS SLE Services

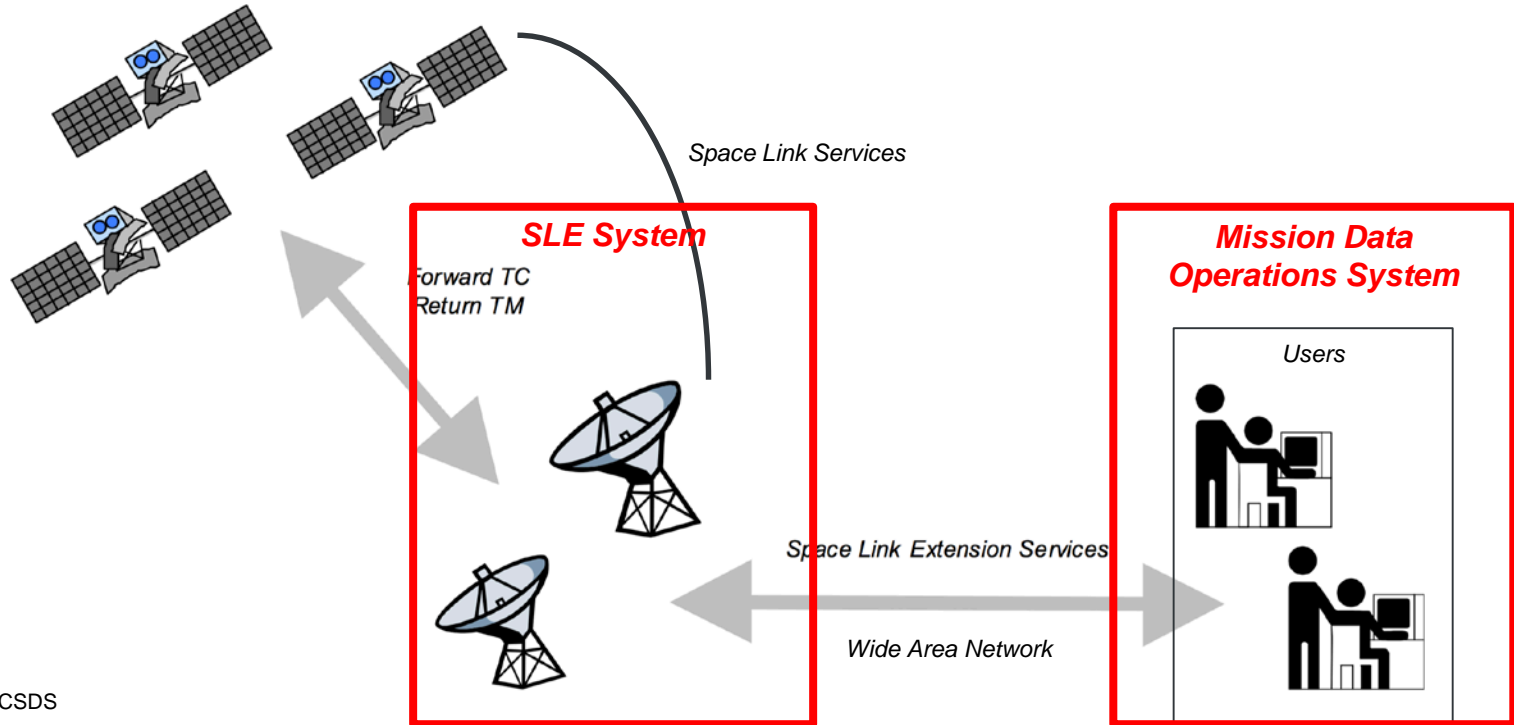


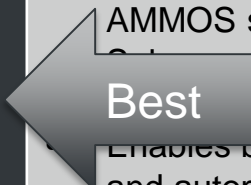
Image Credit: CCSDS

Choosing the Right Approach

Use third-party SLE library

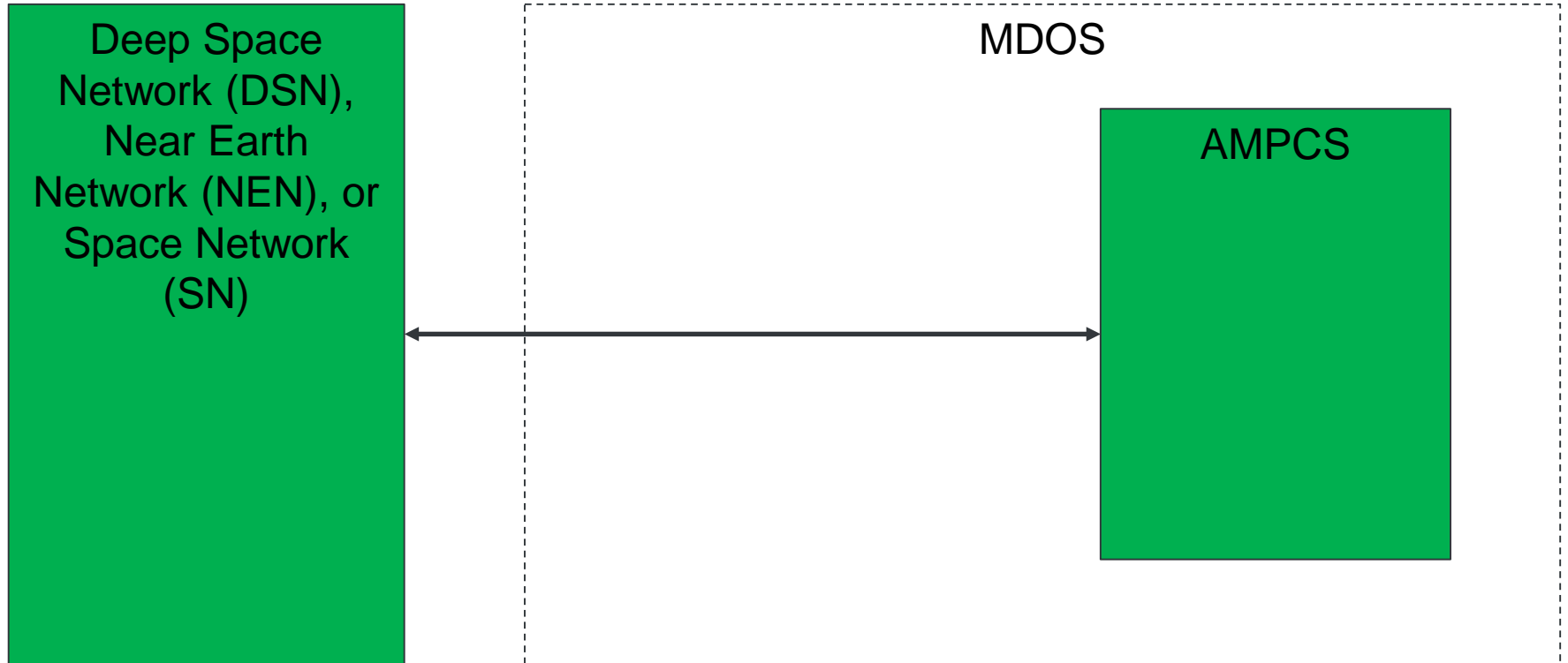
- LSE Space's *SLE User Framework*
- Commercial product: Requires purchase of license

Approach	Pros	Cons
Integrate SLE interface into AMPCS	<ul style="list-style-type: none"> • No new application to deploy and manage 	<ul style="list-style-type: none"> • AMPCS R7.x's uplink model conflicts with SLE FCLTU model • Largest development and test effort • Most difficult to integrate into R8, if desired
Standalone Java application with built-in GUI	<ul style="list-style-type: none"> • Simple • Matches application architecture and look-and-feel of existing AMPCS applications 	<ul style="list-style-type: none"> • Difficult to achieve automation objectives
Web application hosted on an Apache Tomcat server	<ul style="list-style-type: none"> • Recently demonstrated by another AMMOS software and proven to work • Meets security needs (by using AMMOS Access Manager) • Enables both web user interface (WUI) and automation • Easier management 	<ul style="list-style-type: none"> • Different UI technology than rest of AMPCS

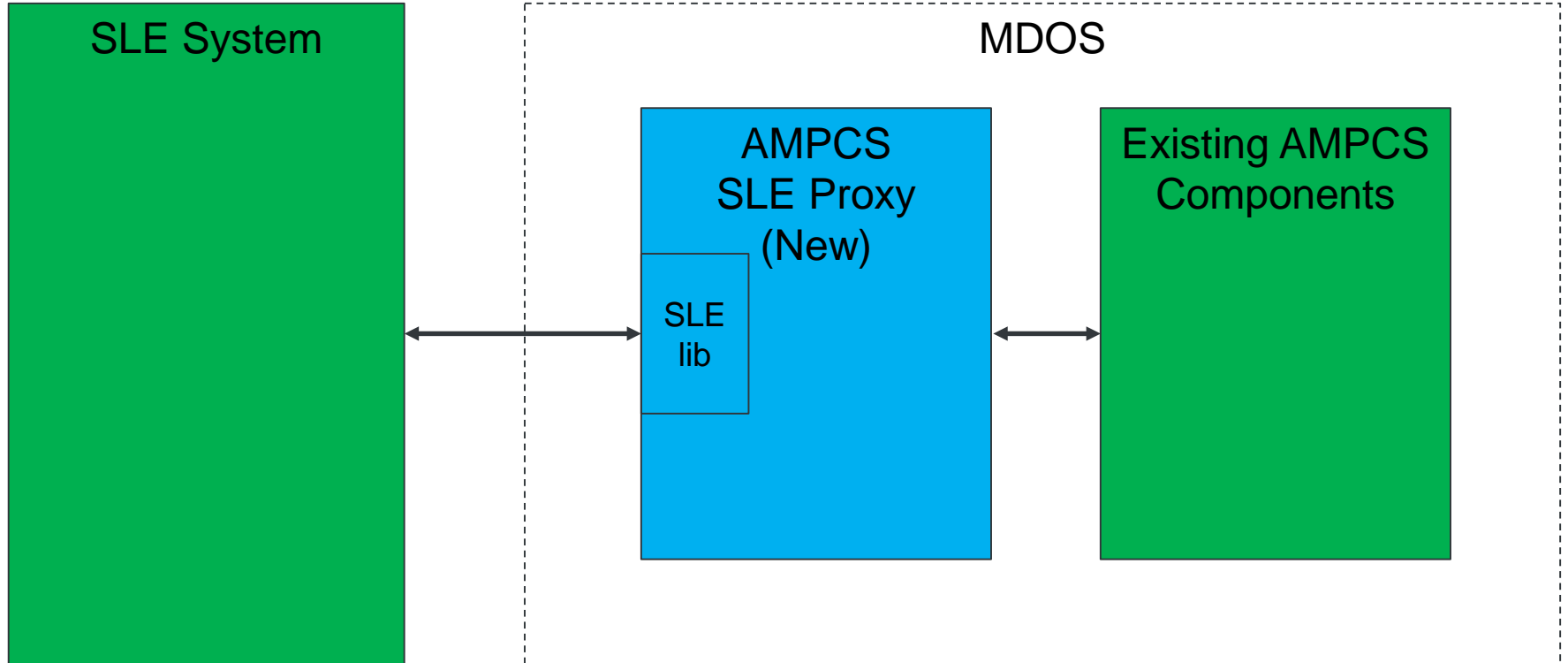


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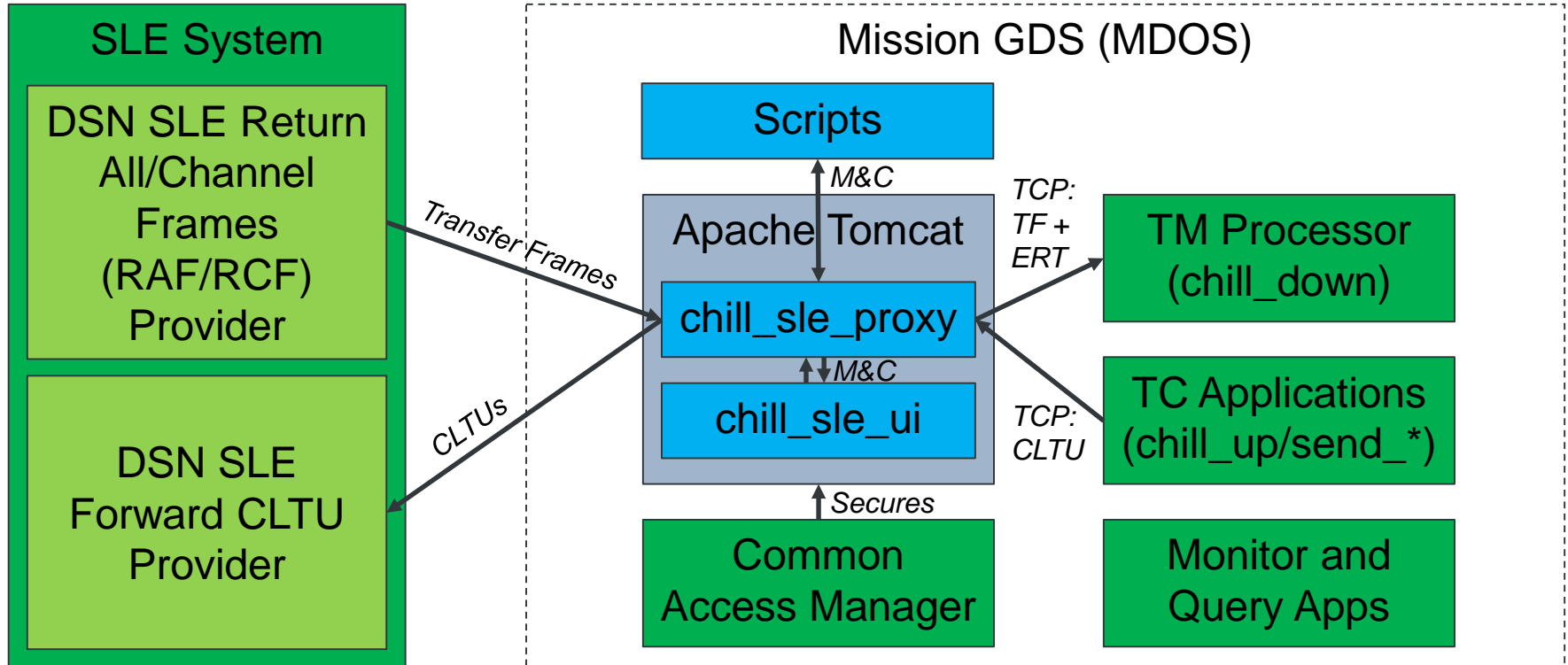
Concept – Legacy



Concept – SLE



Applications View



chill_sle_proxy Features

- SLE service profiles management
 - Profile “dss34-raf”: Service instance ID “sagr=123.spack=ampcs...”, provider host “...”, etc.
- SLE service state management and data transfer operations
 - BIND, UNBIND, START, STOP, PEER-ABORT, THROW-EVENT, GET-PARAMETER, etc.
- Support forward direction and return direction SLE services simultaneously
- Uplink server for AMPCS TC applications
- Client application to the AMPCS TM application (chill_down)
- Support AMPCS TC and TM simultaneously
- Provide configuration and state information, log messages upon query
- RESTful application programming interface (API)
- Real-time monitor data via WebSocket

chill_sle_ui Features

- Platform independent graphical web UI
- Many instances can run simultaneously and receive same updates (benefit of WebSocket)
- Minimize data entry
 - Example: BIND, START, etc. operations are single button clicks
- Correlated information for both sides of interface
 - Can see all uplink parameters/state and all downlink parameters/state
- Provide feedback for SLE operations to same UI (versus legacy/other) that initiated those operations
- Under the hood: HTML5, JavaScript, CSS, Semantic UI, jQuery, DataTables, and WebSocket

chill_sle_ui

Monitor and Control

Chill SLE Proxy Monitor and Control Manage Service Providers

Configuration — Return Provider: [redacted] Forward Provider: [redacted]

▼ State

	Return Provider	Forward Provider	AMPCS Downlink	AMPCS Uplink
Current State:	Active	Active	Connected	Enabled
State Change Time:	2017-032721:42:46.518	2017-032717:58:46.195	2017-032721:42:19.535	2017-032721:48:38.064
Last Data Time:	2017-032721:50:21.021	2017-032721:48:57.310	2017-032721:50:21.022	2017-032721:48:48.350
Data Count:	385	115	385	115
Connection Number:	14	5	N/A	N/A

Current New

Mod Index:

Bitrate:

Reset Apply

Action:

Bind Unbind

Start Stop

Abort

Bind Unbind

CMD Mod On CMD Mod Off

Range Mod On Range Mod Off

Start Stop

Abort

Connect Disconnect

Enable Disable

▼ Message

Auto-scroll:

Search:

Time	Type	Message
2017-032721:49:44.753	INFO	[F5] SLE interface forward service received an event: STATUS REPORT. SIID: [redacted] cltu-last-processed: 114, cltu-last-OK: 114, cltu-status: RADIATED, radiation-start-time: 2017-032721:48:57.279, radiation-stop-time: 2017-032721:48:57.288, production-status: OPERATIONAL, uplink-status: NOT_AVAILABLE, number-of-cltus-received: 115, number-of-cltus-processed: 115, number-of-cltus-radiated: 115, cltu-buffer-available: 51200
2017-032721:49:52.950	INFO	[R14] SLE interface return service received an event: STATUS REPORT. SIID: [redacted] number-of-error-free-frames-delivered: 338, number-of-frames-delivered: 338, frame-sync-lock-status: UNKNOWN, symbol-sync-lock-status: UNKNOWN, subcarrier-lock-status: UNKNOWN, carrier-lock-status: UNKNOWN, production-status: RUNNING
2017-032721:49:54.752	INFO	[F5] SLE interface forward service received an event: STATUS REPORT. SIID: [redacted] cltu-last-processed: 114, cltu-last-OK: 114, cltu-status: RADIATED, radiation-start-time: 2017-032721:48:57.279, radiation-stop-time: 2017-032721:48:57.288, production-status: OPERATIONAL, uplink-status: NOT_AVAILABLE, number-of-cltus-received: 115, number-of-cltus-processed: 115, number-of-cltus-radiated: 115, cltu-buffer-available: 51200
2017-032721:50:02.950	INFO	[R14] SLE interface return service received an event: STATUS REPORT. SIID: [redacted] number-of-error-free-frames-delivered: 355, number-of-frames-delivered: 355, frame-sync-lock-status: UNKNOWN, symbol-sync-lock-status: UNKNOWN, subcarrier-lock-status: UNKNOWN, carrier-lock-status: UNKNOWN, production-status: RUNNING
		[F5] SLE interface forward service received an event: STATUS REPORT. SIID: [redacted] cltu-last-processed: 114, cltu-last-OK: 114, cltu-status: RADIATED, radiation-

Current UTC: 2017-032721:50:22

chill_sle_ui

Monitor and Control – Configuration Expanded

Configuration

SERVICE PROVIDERS

	Return	Forward
Profile Name:	raf-onlc1	uplink-prof
Host:		
Port:		
Instance ID:		
Provider Auth Mode:		
Provider Name:		
User Auth Mode:		
User Name:		
Return Type:	RETURN_ALL	
Start Time:	Start Time	
Stop Time:	Stop Time	
Frame Quality:	ALL	

AMPCS

	Downlink	Uplink
Host:	jpl.nasa.gov	Uplink Host
Port:		8899

Edit Downlink Config

chill_sle_ui

Monitor and Control – State

▼ State

	Return Provider	Forward Provider	AMPCS Downlink	AMPCS Uplink
Current State:	Active	Active	Connected	Enabled
State Change Time:	2017-032T21:42:46.518	2017-032T17:58:46.195	2017-032T21:42:19.535	2017-032T21:48:38.064
Last Data Time:	2017-032T21:53:27.279	2017-032T21:48:57.310	2017-032T21:53:27.279	2017-032T21:48:48.250
Data Count:	691	115	691	115
Connection Number:	14	5	N/A	N/A

Action:

Current New

Mod Index:

Bitrate:

Reset Apply

Bind Unbind

Start Stop

Abort

CMD Mod On CMD Mod Off

Range Mod On Range Mod Off

Start Stop

Abort

Connect Disconnect

Enable Disable

chill_sle_ui

Manage Service Providers

Chill SLE Proxy Monitor and Control **Manage Service Providers**

+ Add Edit Delete

Search:

Profile Name	Profile Type	Host	Port	Instance ID	Provider Auth Mode	Provider Name	User Auth Mode	User Name	Return Type	Start Time	Stop Time	Frame Version	Frame Quality	SC ID	VC ID
dsnsle-test	RETURN								RETURN_ALL	2016-285T00:02:47.000	2016-294T00:13:36.000		GOOD		
raf-off1	RETURN								RETURN_ALL	2016-285T00:01:36.000	2016-294T21:46:36.445		GOOD		
raf-onlc1	RETURN								RETURN_ALL				ALL		
rcfv2-onlt2	RETURN								RETURN_CHANNEL			1		1	0
test_profile_1	RETURN								RETURN_CHANNEL			1		1	
uplink-prof	FORWARD														

Showing 1 to 6 of 6 entries

Current UTC: 2017-32T21:57:20

RESTful Monitor and Control

- Representational state transfer (REST) monitor and control API accommodates both WUI and automation scripts
- Using Restlet, open source REST framework for Java
- Example APIs:
 - GET /sle-proxy/sle-interface/profiles/dss34-raf
 - PUT /sle-proxy/sle-interface/profiles/dss34-fcltu + JSON body of new SLE service profile
 - POST /sle-proxy/chill-interface/config + JSON body 'downlink-host: chilldownhost1'
 - POST /sle-proxy/sle-interface/forward/action/bind?profile=dss34-fcltu
 - POST /sle-proxy/sle-interface/forward/action/start
 - POST /sle-proxy/sle-interface/forward/action/throw?change-rate=125&change-index=930
 - POST /sle-proxy/chill-interface/downlink/action/connect
 - GET /sle-proxy/messages?from-time=2017-065T12:00:00

RESTful Monitor and Control

- Representational state transfer (REST) monitor and control API accommodates both WUI and automation scripts
- Using Restlet, open source REST framework for Java
- Example APIs:
 - GET /sle-proxy/sle-interface/profiles/dss34-raf
 - PUT /sle-proxy/sle-interface/profiles/dss34-fcltu + JSON body of new SLE service profile
 - POST /sle-proxy/chill-interface/config + JSON body 'downlink-host: chilldownhost1'
 - POST /sle-proxy/sle-interface/forward/action/bind?profile=dss34-fcltu
 - POST /sle-proxy/sle-interface/forward/action/start
 - POST /sle-proxy/sle-interface/forward/action/throw?change-rate=125&change-index=930
 - POST /sle-proxy/chill-interface/downlink/action/connect
 - GET /sle-proxy/messages?from-time=2017-065T12:00:00

Automation

- REST APIs naturally become automation hooks

```
#fcltu-test.py
```

```
...
```

```
content = subprocess.check_output('curl -b ~/sso_cookie.txt -k -X POST -sL  
"https://sleproxy.jpl.nasa.gov/sle-proxy/sle-  
interface/forward/action/bind?profile=dss34-fcltu"  
, shell=True)  
data = json.loads(content)
```

```
...
```

Access Control

- AMMOS Common Access Manager (CAM) applies access control on web resources
- Control policies applied on Lightweight Directory Access Protocol (LDAP) users and groups
- Two LDAP groups: *chill-sle-proxy.read* and *chill-sle-proxy.write*
 - GET granted to “read” group
 - GET, PUT, POST, and DELETE granted to “write” group
- Gives SLE controllers and control scripts full access, while limiting monitoring users and non-control scripts to viewing only

Planning, Development, and Test

- Weekly WebEx meetings held between JPL and APL
- APL reviewed the requirements and design
- Two JPL engineers working half-time on development
 - Development started late-August 2016, finished on October 31 (10 weeks)
- One JPL test engineer coordinating testing
- Two APL engineers wrote test procedures and test scripts, now performing them
- Two testbeds:
 - LSE Space's *SSPsim* (simulated data, our own VMs, outside of Flight Ops network)
 - DSN's forward and return SLE providers in test environment (real MESSENGER data, providers are identical to production, inside Flight Ops network)

Conclusion

- Many benefits to choosing a web-based approach to enable SLE services in an already established GDS
 - Recommend wider use of RESTful APIs and WUIs
 - Free frameworks are available that can significantly minimize development and test
- Web apps don't have to be limited to UI/client apps
 - Telemetry- and telecommand-handling, backend-like apps work well also
- Provides early data points for AMPCS R8 design and planning
 - Use of commercially-licensed third-party products
- Demonstrated the great synergy that is possible when different organizations working for NASA work together

Acknowledgments

Authors would like to thank Patricia Harrington-Duff¹, Arthur “Norm” Tuttle¹, Luis Campos², and Ashley Shamilian² for their testing-related work on this task, which is crucial to the successful delivery of *chill_sle_proxy* and *chill_sle_ui*.

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