YumaPro SDK Developer Training

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2015-10-15

Agenda

- Intro/Big Picture
- YANG Tutorial
- Getting Started with Server Development
- RPC Processing
- Notifications
- Retrieval Operations
- Transaction Model
- Edit Operations
- Error Handling
- SIL Control
- SIL Debugging

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Part 1: Intro/Big Picture

- Intro/Big Picture
- YANG Tutorial
- Getting Started with Server Development
- RPC Processing
- Notifications
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- SIL Debugging

Introduction

- Remote Control
- Configuration, Operational Data and Notifications
- Evolution of CLI, SNMP into NETCONF
- What are the standards to know?
- What are the YumaPro Tools?
- Install YumaPro SDK

Remote Control

- Asynchronous network management
  - Management application uses a shared or dedicated network to communicate with managed devices
  - Security set up in advance
    - Usually console login or flash drive
  - Management protocols send commands for specific data
    - Client and server must agree on the syntax and semantics of this data

Configuration

- Called the intended configuration
  - Instructions to the device
    - Some vendors this is only client instructions
  - YANG: config=true data nodes
- Transferable
  - Load config into new device to clone
- Offline validation and manipulation
  - Get config, edit offline, push config
- EntityTag and LastModified meta-data maintained by the server

Operational State

- YANG: config=false data nodes
- Divided into
  - Applied configuration
  - Statistics
  - Derived state
- No EntityTag or LastModified meta-data maintained by the server

Notifications

- YANG: notification statement
- Data model specific events
- Not a subscription to a resource that has changed
  - Pub/sub updates resources
  - YANG notifications report events
- Not private
  - Any subscriber can access all events; no private events for 1 session

Evolution

- CLI over telnet was first; SSH came later
- CLI mandatory to provide complete functional coverage
- SNMP added monitoring based on data models
- Configuration in CLI and monitoring in SNMP causes problems (data naming, RowStatus, etc.)
- YANG is a better fit for configuration
- Large effort in progress to standardize YANG-based configuration and monitoring data models

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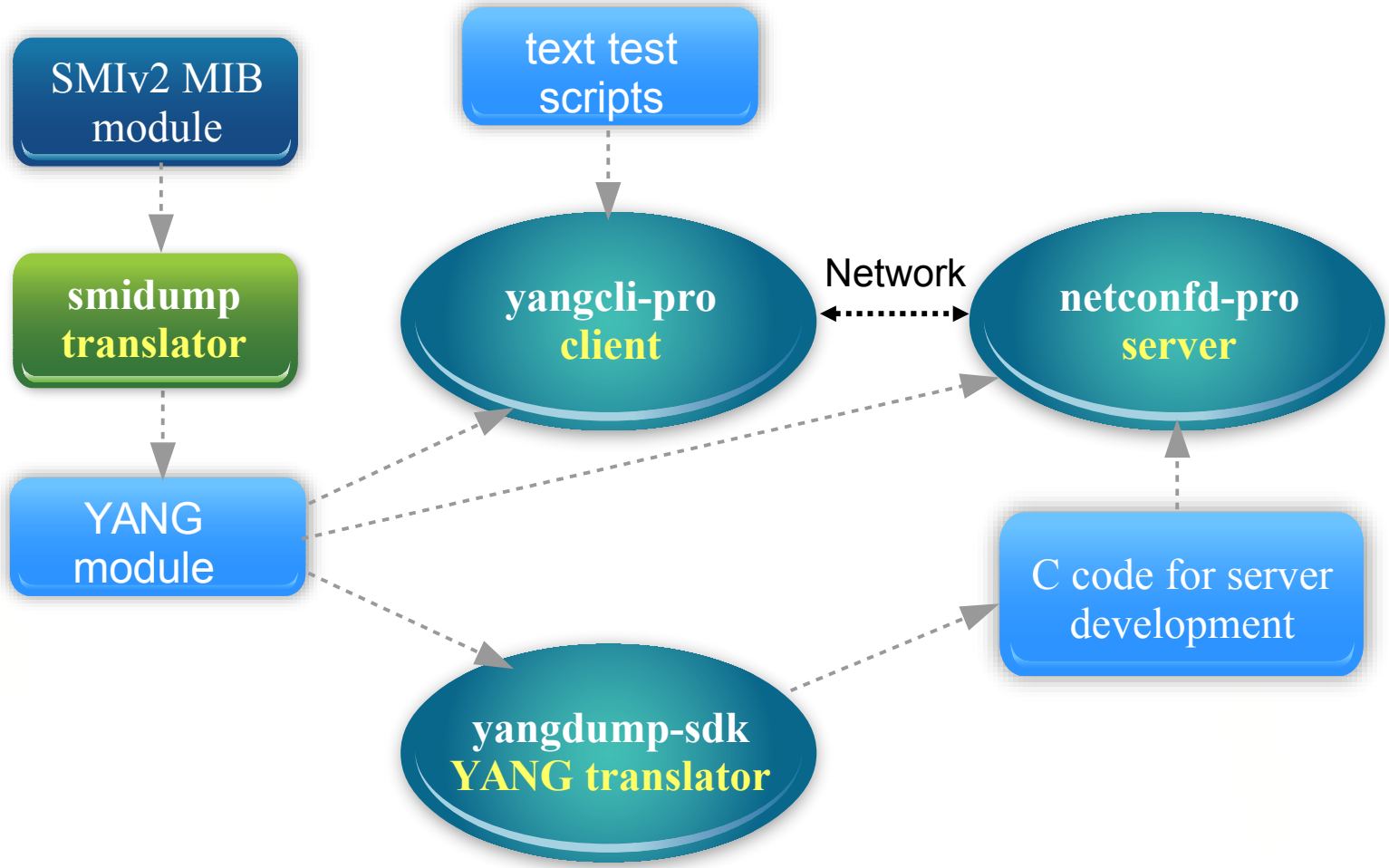
Standards

- Current
  - NETCONF/YANG
  - XML/XPath
- Almost Here
  - RESTCONF/JSON
- Near Future
  - CoMI/CBOR/YANG Hash

YumaPro SDK

Core Tools



Download Packages

- https://www.yumaworks.com/dld
  - user: training
  - password: see whiteboard
  - yumapro-sdk/14.08-9
  - yumapro-doc/14.08-9

Installing YumaPro

- Refer to YumaPro SDK Installation Guide
- Install library dependencies
- Install yumapro-sdk and yumapro-doc packages
- Update SSH and Apache configurations
- Install netconfd-pro.conf

YumaPro Installation Guide

netconfd-pro.conf

- Server configuration file
  - default: /etc/yumapro/netconfd-pro.conf
  - CLI parameters override config file values
  - --config=*filespec* overrides default config file
- Start config file from sample
  - cd /etc/yumapro
  - sudo cp netconfd-pro-sample.conf netconfd-pro.conf

netconfd-pro Sec. 3, CLI Reference

Running YumaPro

- Start the server
  - netconfd-pro –log-level=debug4
- Start yangcli-pro and connect to the server
- Try some commands like get, get-config
- Special files
  - $HOME/.yumapro files
  - /tmp/ncxserver.sock
  - YUMAPRO_HOME/modules
  - /usr/share/yumapro
  - /usr/lib/yumapro

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Getting Help

- Several sources of help (besides the manuals!)
  - netconfd-pro
    - netconfd-pro –help
    - man netconfd-pro
  - yangcli-pro
    - yangcli-pro –help
    - man yangcli-pro
    - help command
    - tab key for command completions
    - ? key for command completion help

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Documentation

- /usr/share/doc/yumapro
  - YumaPro Installation Guide
  - YumaPro Quickstart Guide
  - YumaPro User Manual
  - YumaPro netconfd-pro Manual
  - YumaPro yangcli-pro Manual
  - YumaPro yangdiff-pro Manual
  - YumaPro yangdump-pro Manual
  - YumaPro Developer Manual
  - YumaPro yp-system API Guide
  - YumaPro yp-show API Guide

Part 2: YANG Tutorial

- Intro/Big Picture
- YANG Tutorial
- Getting Started with Server Development
- RPC Processing
- Notifications
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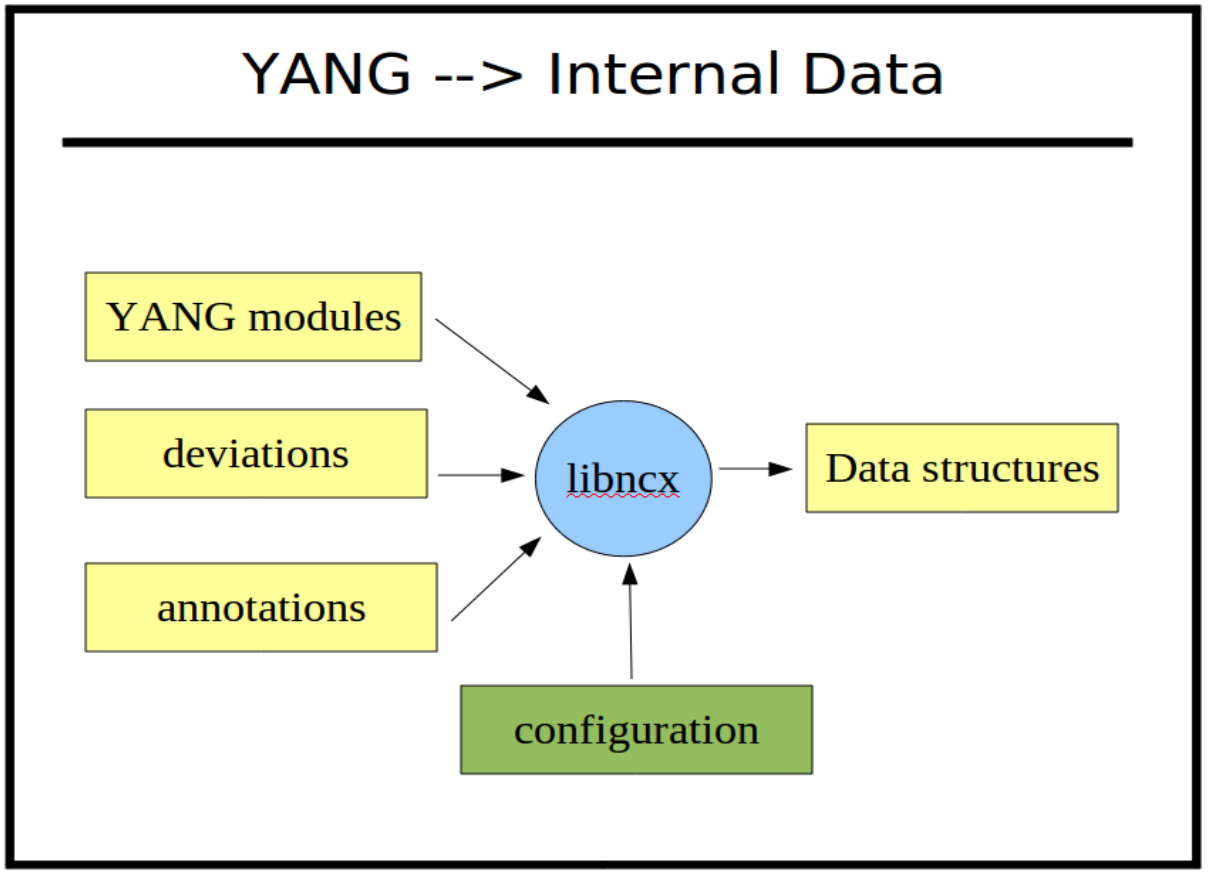
- SIL Control
- SIL Debugging

YANG

- Switch to Netconf Central slide deck
- http://dld.netconfcentral.org/doc/ncorg_netconf_yang_tutorial.pdf

YumaPro YANG Processing



Part 3: Getting Started

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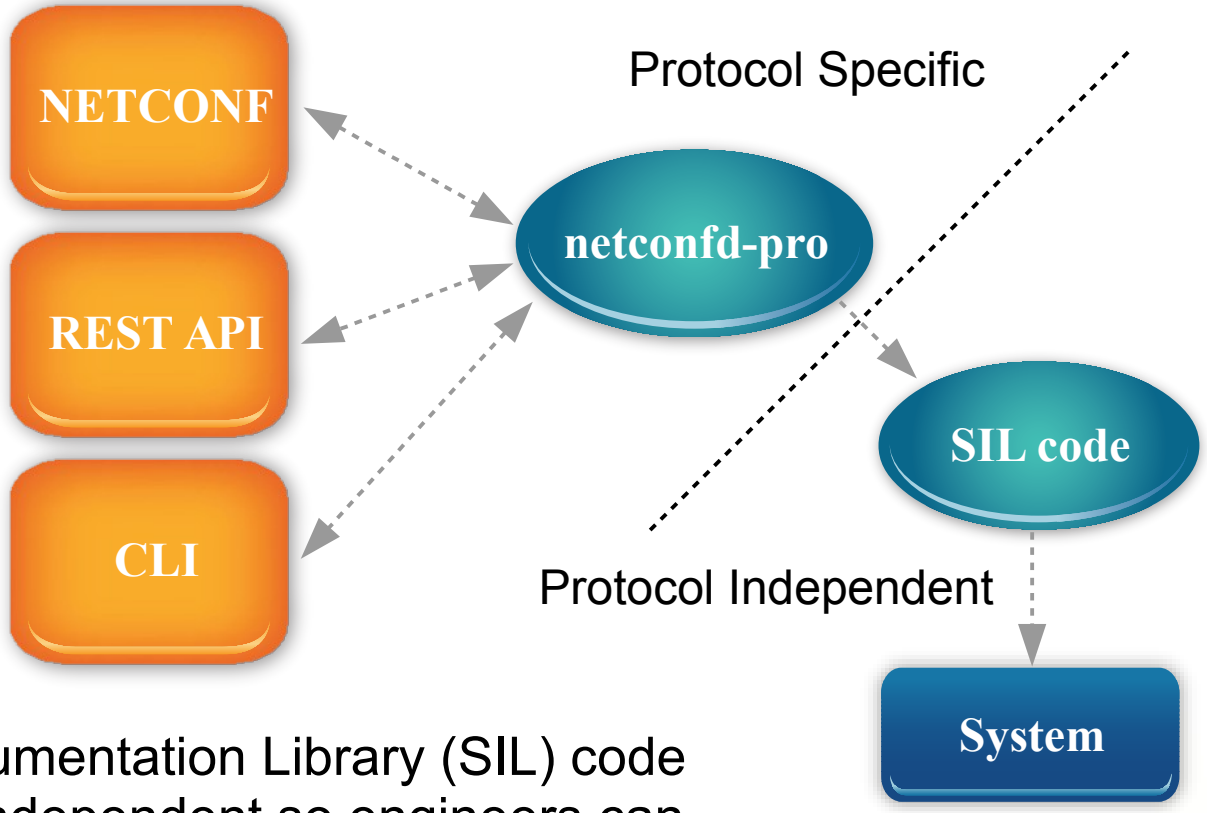
Server Development

- Pick 1 or more YANG modules to implement
- Decide which type of SIL variant is needed
- Generate the C Code Stubs
- Fill in the callback functions

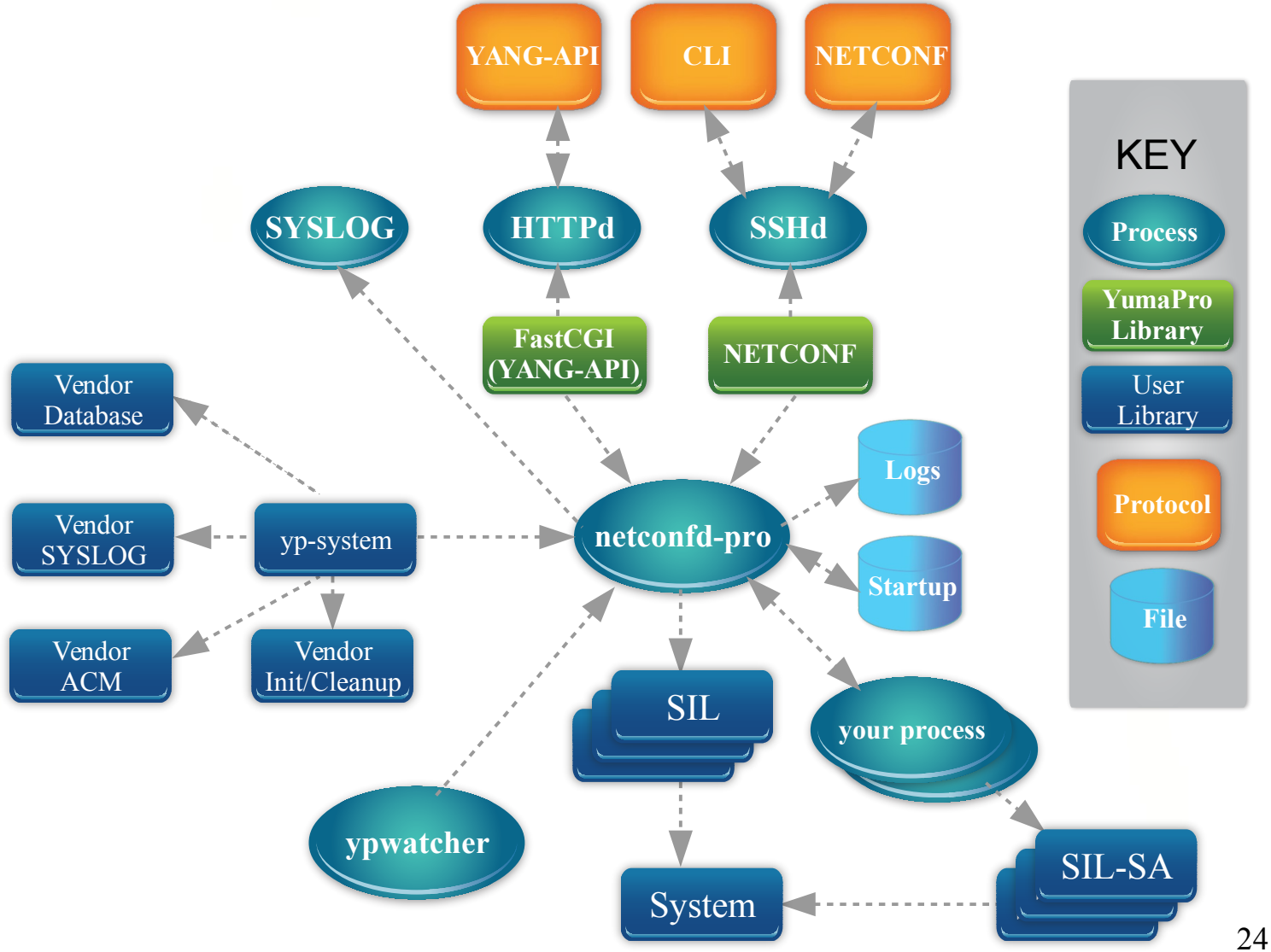
YumaPro Server
Unified API



Server Instrumentation Library (SIL) code is protocol-independent so engineers can focus on managing the system, not all the management protocols

YumaPro SDK

server: netconfd-pro



YumaPro Server
Major Features

- Redesigned for Multi-protocol support
  - CLI, NETCONF, REST APIs
  - XML and JSON encoding
- Distributed Transaction Engine
  - Full YANG validation, optimized for speed
  - Local (SIL) and remote (SIL-SA) callbacks
  - Automatic complex rollback
- Distributed System Integration
  - System Integration Library
  - Multiple Sub Agents
  - External Database

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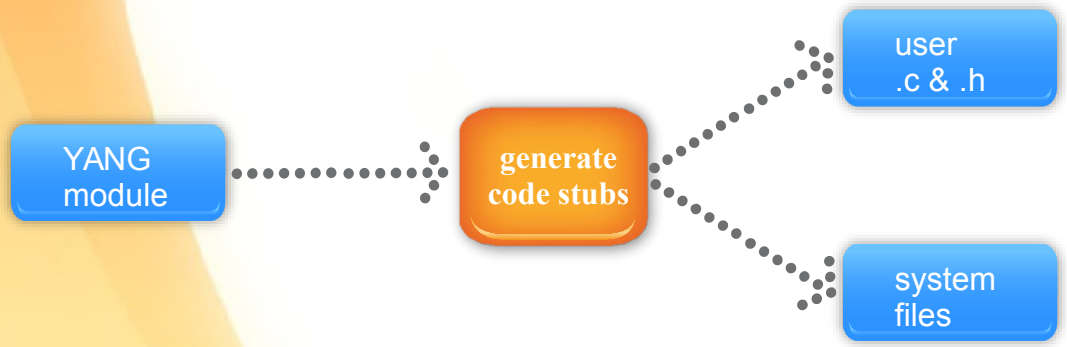
YumaPro Server
Standards Based

- Full NETCONF standards support
  - NETCONF Protocol (RFC 6241)
  - NETCONF over SSH (RFC 6242)
  - NETCONF Access Control Model (RFC 6536)
  - NETCONF Monitoring (RFC 6022)
  - NETCONF Notifications (RFC 5277)
  - NETCONF Base Notifications (RFC 6470)
  - Partial Lock RPC for NETCONF (RFC 5717)
  - With-defaults Capability (RFC 6243)
  - YANG Data Modeling Language (RFC 6020)
  - Common YANG Data Types (RFC 6991)

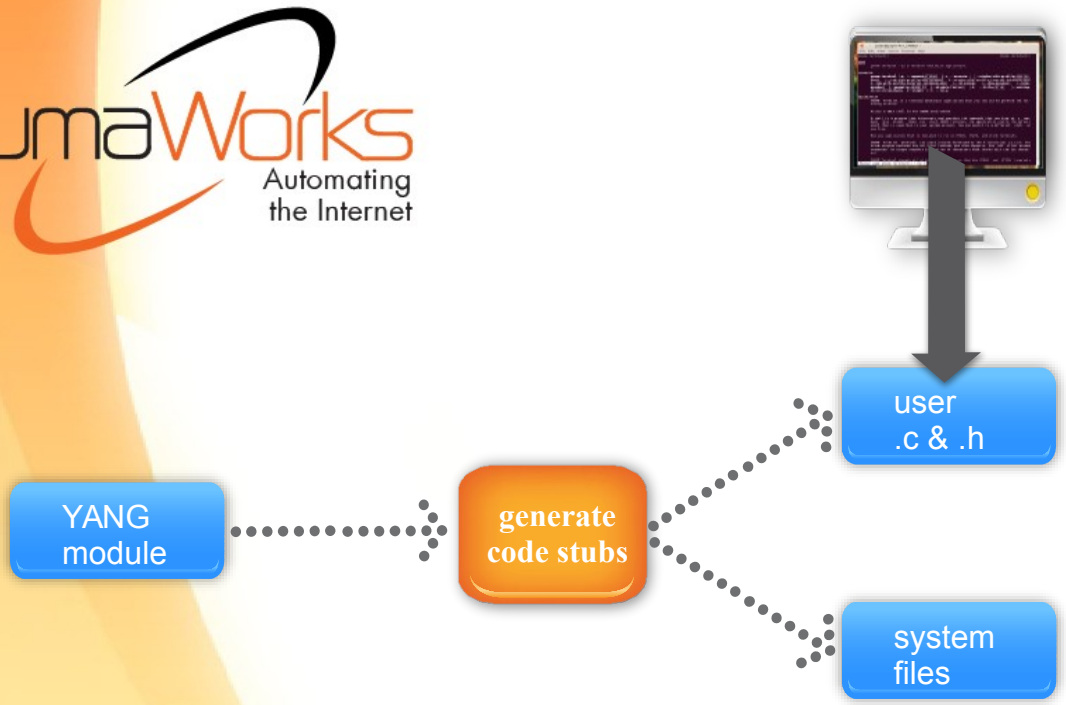
YumaWorks Solves Management Plane Automation

Regular YANG modules are used to create code stubs:
- system
- user



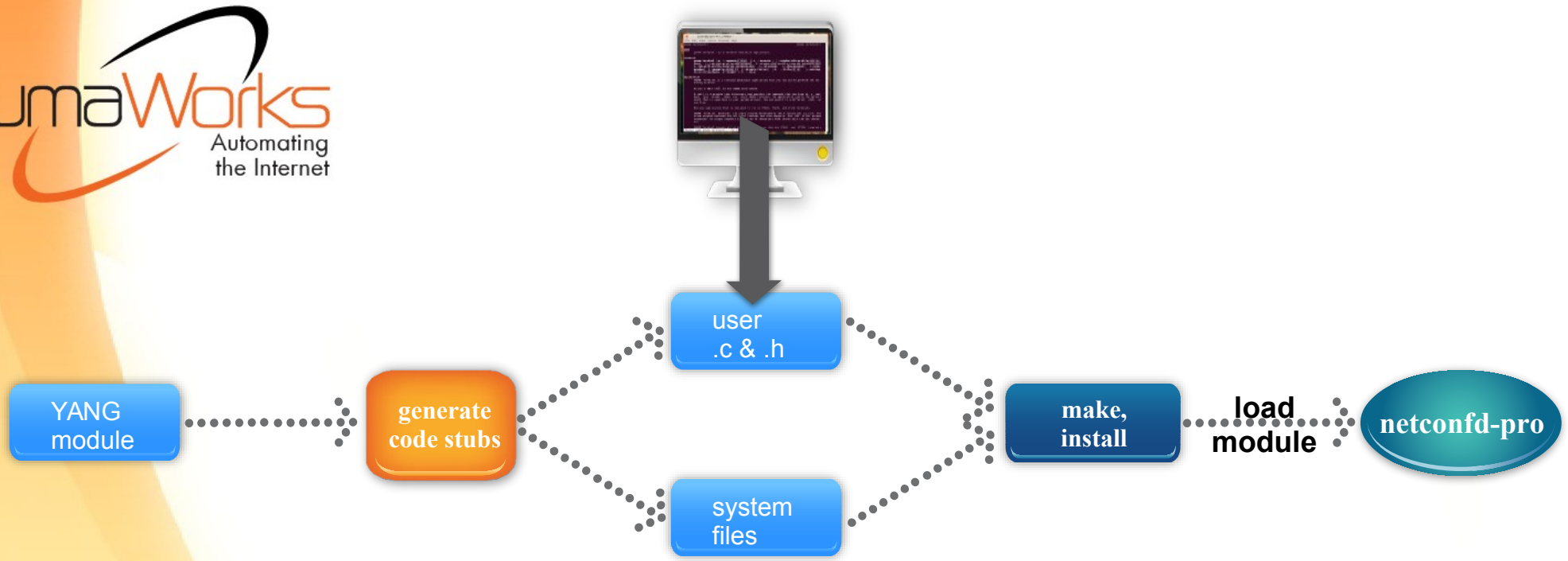
YumaWorks Solves Management Plane Automation

Developers only focus on development of product specific functions:
- database manipulation
- device instrumentation
- undo device instrumentation



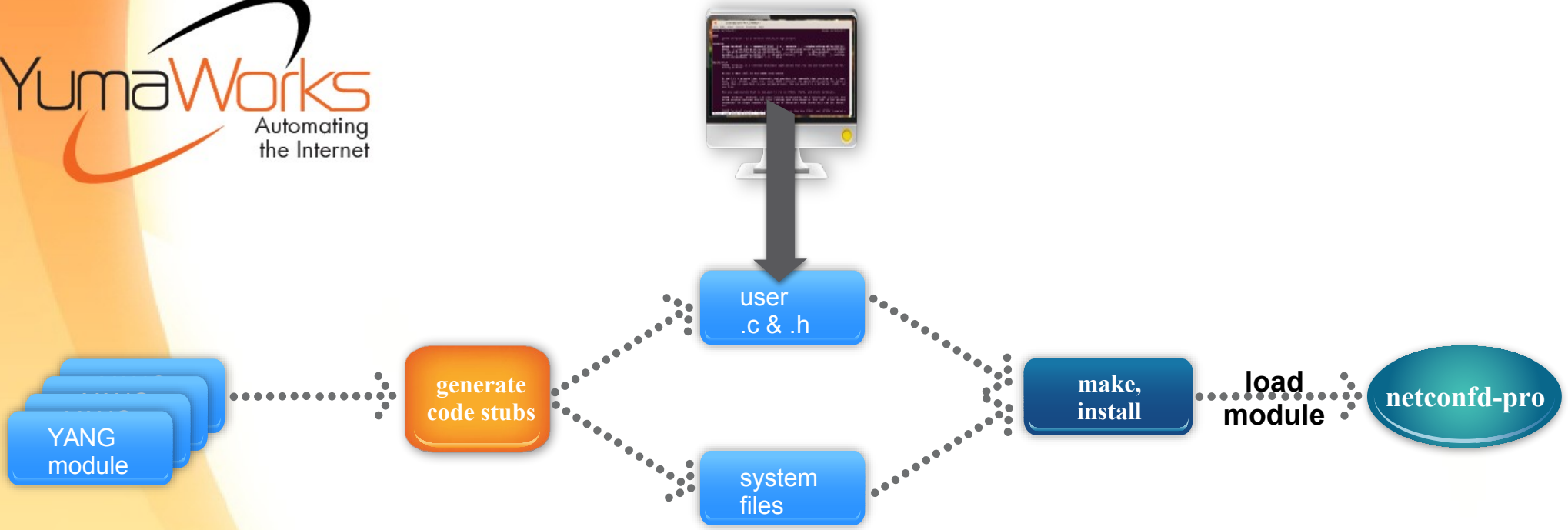
YumaWorks Solves Management Plane Automation

The user and system code is then built into a dynamically loadable library – a SIL (Server Instrumentation Library) and for distributed Systems a SIL-SA (SIL-Sub Agent).



YumaWorks Solves Management Plane Automation

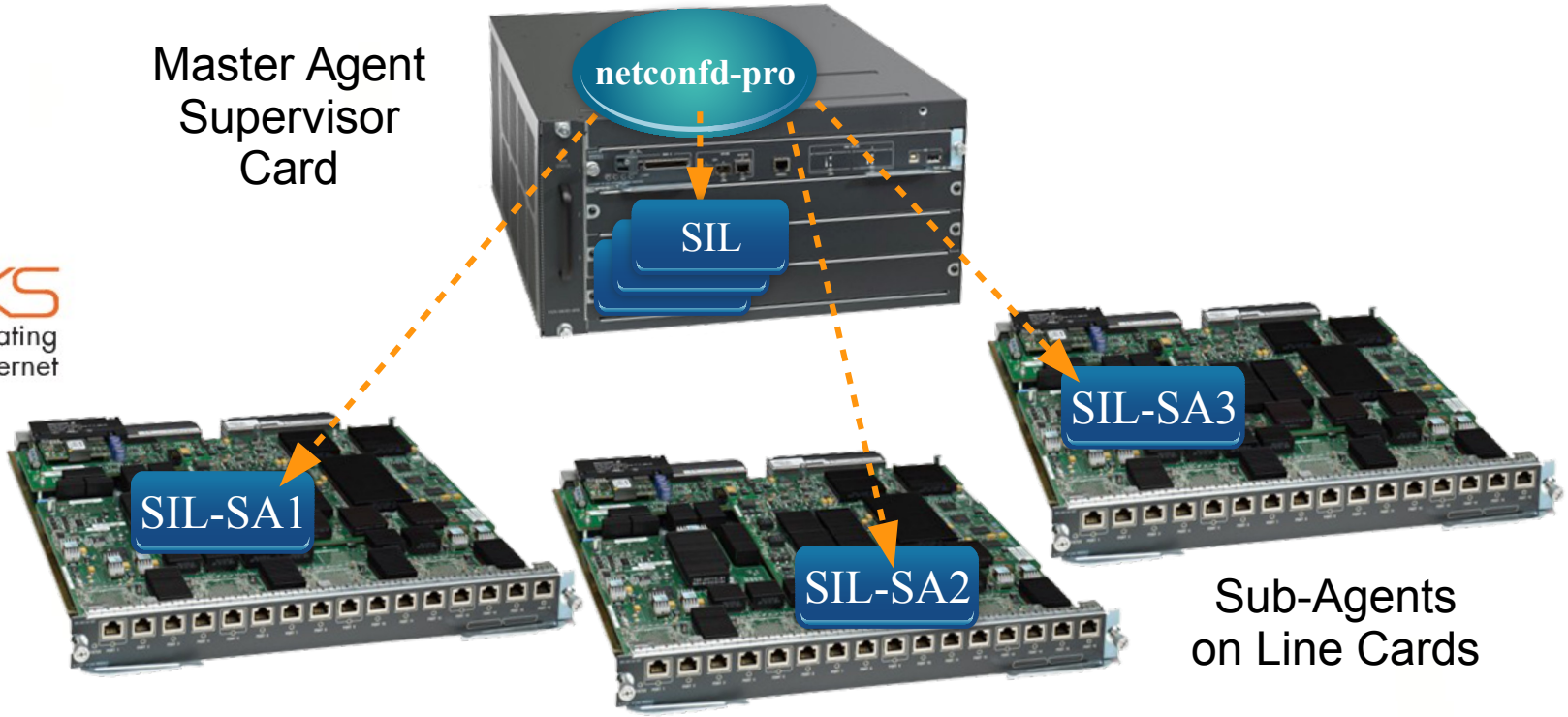
Bundles can group collections of YANG modules together into a dynamic library that can be loaded with one command.



SIL Code

- Server Instrumentation Library
  - Implements user callbacks for YANG objects
  - Used to hook data model into the underlying system
  - When server loads a module or bundle, it looks for the associated SIL library (using naming conventions)
  - libdy (dynamic load) used to avoid compile-time coupling to SILs

Distributed Transaction Management



Asynchronous Sub-Agent Support (SIL-SA)

SIL vs. SIL-SA Code

- SIL== Main Server
  - Synchronous instrumentation
- SIL-SA – Sub-Agent
  - Asynchronous (distributed) instrumentation
  - Same as SIL, except runs in a separate process over the YControl protocol

Module vs. Bundle

- A SIL bundle contains SIL or SIL-SA code for multiple YANG modules
  - Needed in order to auto-generate C code for augments
  - Allows multiple modules to be loaded into the server as a single package
    - --bundle=ietfInterfacesBundle

make_sil_dir Scripts

- Scripts to generate the instrumentation library:
  - make_sil_dir_pro
    - 1 module, SIL or SIL-SA code
  - make_sil_bundle
    - N modules, SIL or SIL-SA code

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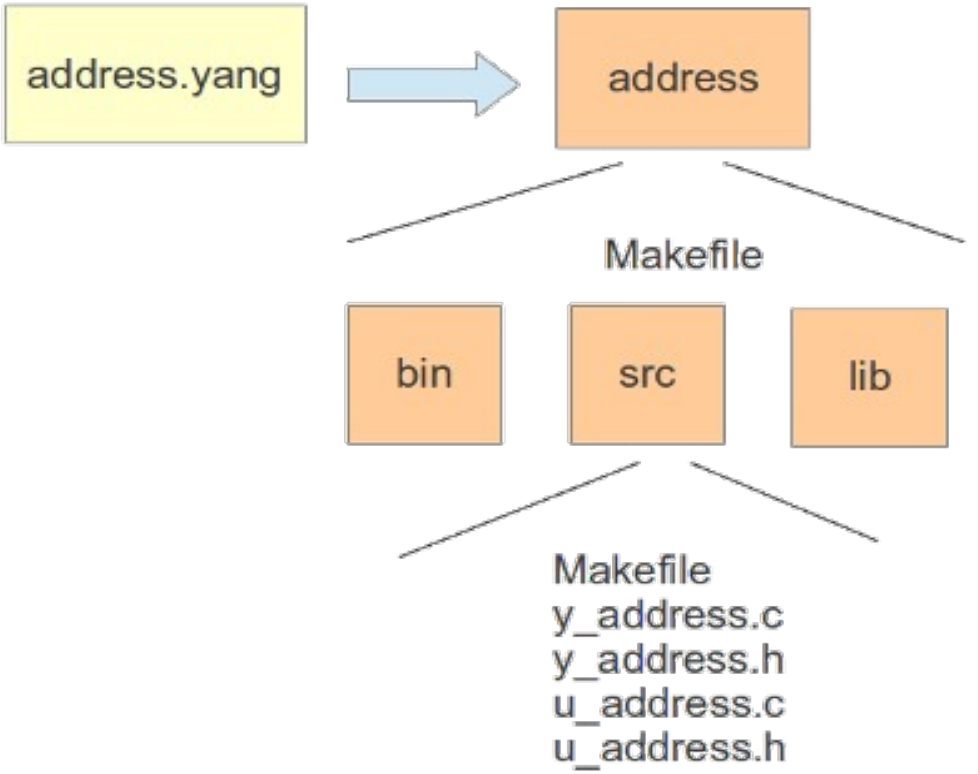
make_sil_dir_pro

- 1 module for SIL or SIL-SA code
  - make_sil_dir_pro [--split] *module-name* [extra-parms]
  - extra-parms
    - deviation=*deviation-module-name*
    - --sil-sa
    - --sil-get2
    - --sil-edit2
    - --sil-include=*include-spec*
    - other yangdump-sdk parameters

Developer Sec. 2, SDK Quickstart

SIL Example

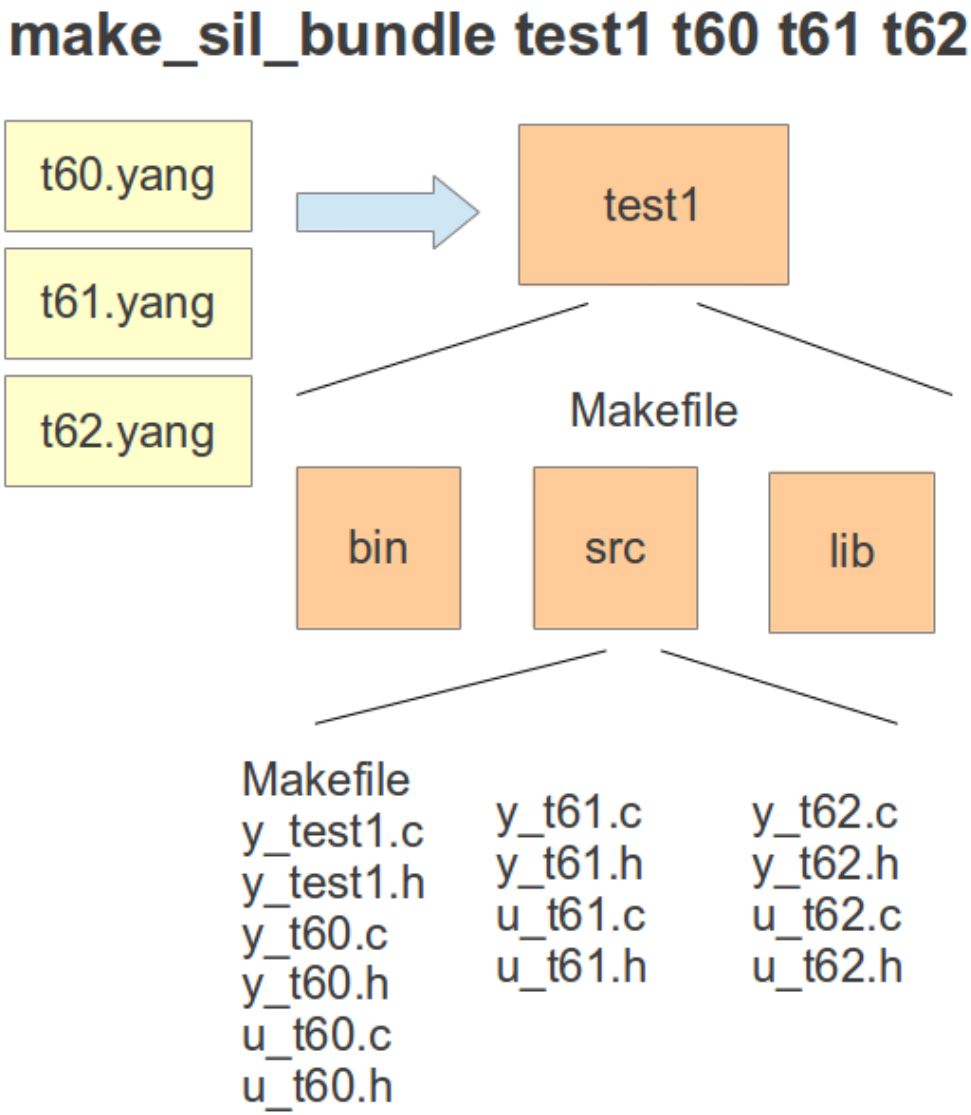


make_sil_bundle

- N modules for SIL or SIL-SA code
  - make_sil_bundle bundle-name *module-name [module-name]** [extra-parms]
  - base module first, augmenting modules last
  - extra-parms
    - deviation=*deviation-module-name*
    - --sil-sa
    - --sil-get2
    - --sil-edit2
    - --sil-include=*include-spec*
    - other yangdump-sdk parameters

Developer Sec. 2, SDK Quickstart

SIL Bundle Example



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make_sil_sa_dir

- 1 module for SIL-SA code
  - make_sil_sa_dir [--split] *module-name* [extra-parms]
  - extra-parms
    - deviation=*deviation-module-name*
    - --sil-get2
    - --sil-edit2
    - --sil-include=*include-spec*
    - other yangdump-sdk parameters

make_sil_sa_bundle

- N modules for SIL-SA code
  - make_sil_sa_bundle bundle-name *module-name [module-name]** [extra-parms]
  - base module first, augmenting modules last
  - extra-parms
    - deviation=*deviation-module-name*
    - --sil-get2
    - --sil-edit2
    - --sil-include=*include-spec*
    - other yangdump-sdk parameters

--split Parameter

- Use –split for separate user and yumapro files

A split SIL module for *foo.yang* would be generated using the following files:

File name	Type	Description
u_foo.c	User SIL	User-provided server instrumentation code for the 'foo' module.
u_foo.h	User SIL	User-provided external definitions for the 'foo' module. Should not edit!
y_foo.c	YumaPro SIL	YumaPro server glue code for the 'foo' module. Do not edit!
y_foo.h	YumaPro SIL	YumaPro server external definitions for the 'foo' module. Do not edit!

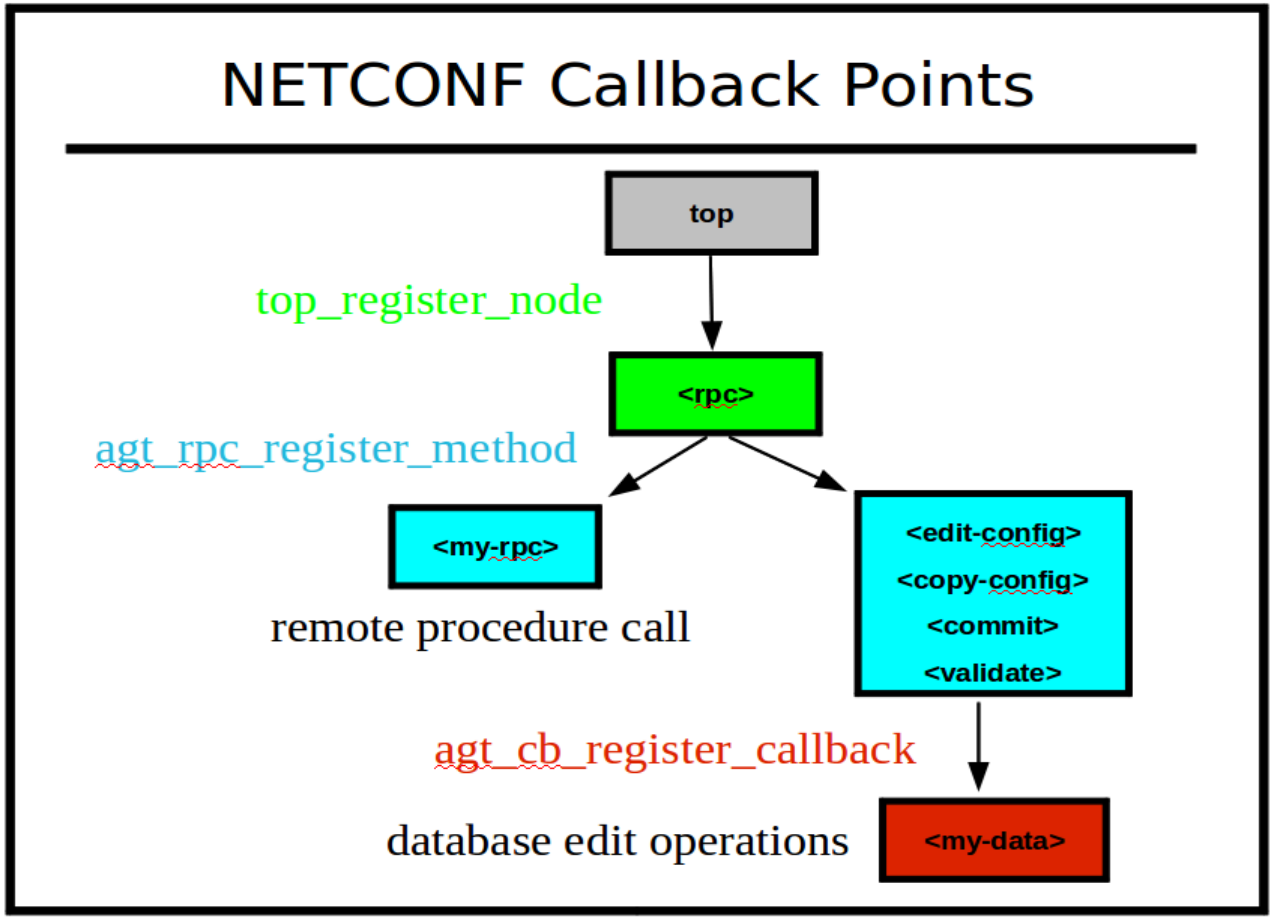
Without --split

- Old style: combined files for full parameter access

A combined SIL module for *foo.yang* would be generated using the following files:

File name	Type	Description
foo.c	Combined YumaPro and User SIL	User-provided server instrumentation code for the 'foo' module.
foo.h	Combined YumaPro and User SIL	User-provided external definitions for the 'foo' module. Should not edit!

SIL Callbacks



make_sil_dir_pro Example

- Create code for ietf-interfaces SIL
  - make_sil_dir_pro --split ietf-interfaces \
    --sil-get2 --sil-edit2
  - cd ietf-interfaces
  - make DEBUG=1
  - sudo make DEBUG=1 install

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SIL APIs

- There are 3 functions a SIL or SIL-SA library are required to implement
  - init1
  - init2
  - cleanup
- init1 is used to load modules, register callbacks, etc.
- init2 is used to load run-time data into the datastore
- cleanup is used to unload the module, free memory, etc.

y_init1

- YumaPro init1 function registers callbacks

```
/********************************************************************
* FUNCTION y_ietf_interfaces_init
*
* initialize the ietf-interfaces server instrumentation library
*
* INPUTS:
*   modname == requested module name
*   revision == requested version (NULL for any)
*
* RETURNS:
*    error status
********************************************************************/
status_t y_ietf_interfaces_init (
   const xmlChar *modname,
   const xmlChar *revision)
{
```

u_init1

- User init1 function caches module pointer

```
status_t u_ietf_interfaces_init (
    const xmlChar *modname,
    const xmlChar *revision)
{
    status_t res = NO_ERR;
    ncx_module_t *ietf_interfaces_mod = NULL;

    ietf_interfaces_mod = ncx_find_module(
        y_ietf_interfaces_M_ietf_interfaces,
        y_ietf_interfaces_R_ietf_interfaces);
    if (ietf_interfaces_mod == NULL) {
        return ERR_NCX_OPERATION_FAILED;
    }

    /* put your module initialization code here */

    return res;

} /* u_ietf_interfaces_init */
```

y_init2

- YumaPro init2 sets up system-created config and operational state

```
static status_t
   agt_if_init2 (void)
{

   if (!agt_if_supported) {
      return NO_ERR;  // ignore module load error
   }

   boolean added = FALSE;
   status_t res = NO_ERR;
   val_value_t *interfacesval =
      agt_add_top_node_if_missing(ifmod, interfaces_N_interfaces,
                                  &added, &res);
   // ignoring added flag because counter hooks need to be added
   if (interfacesval && res == NO_ERR) {
      res = add_interface_entries(interfacesval);
   }

   return res;

} /* agt_if_init2 */
```

u_init2

- User init2 does implementation-specific tasks

```
/********************************************************************
* FUNCTION u_ietf_interfaces_init2
*
* SIL init phase 2: non-config data structures
* Called after running config is loaded
*
* RETURNS:
*    error status
********************************************************************/
status_t u_ietf_interfaces_init2 (void)
{
   status_t res = NO_ERR;

   /* put your init2 code here */

   return res;

} /* u_ietf_interfaces_init2 */
```

y_cleanup

- YumaPro cleanup unregisters callbacks

```
void y_ietf_interfaces_cleanup (void)
{

   agt_cb_unregister_callbacks(
      y_ietf_interfaces_M_ietf_interfaces,
      (const xmlChar *)"/if:interfaces");

   agt_cb_unregister_callbacks(
      y_ietf_interfaces_M_ietf_interfaces,
      (const xmlChar *)"/if:interfaces/if:interface");

   agt_cb_unregister_callbacks(
      y_ietf_interfaces_M_ietf_interfaces,
      (const xmlChar *)"/if:interfaces-state");
```

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u_cleanup

- User cleanup does implementation-specific cleanup tasks

```
/********************************************************************
* FUNCTION u_ietf_interfaces_cleanup
*    cleanup the server instrumentation library
*
********************************************************************/
void u_ietf_interfaces_cleanup (void)
{

   /* put your cleanup code here */

} /* u_ietf_interfaces_cleanup */
```

Part 4: RPC Processing

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RPC Processing

- YANG “rpc” statement used to define all operations
- NETCONF <rpc> and <rpc-reply> messages
- SIL init1 function will register each RPC with “agt_rpc_register_method” function
- Multi-phase RPC callback model
- Processing input
- 3 return variants (ok, data, rpc-error)
- Returning data (data queue or walker callback)
- Post Reply Processing

YANG rpc-stmt

```
rpc-stmt            = rpc-keyword sep identifier-arg-str optsep
                      (";" /
                       "{" stmtsep
                           ;; these stmts can appear in any order
                           *(if-feature-stmt stmtsep)
                           [status-stmt stmtsep]
                           [description-stmt stmtsep]
                           [reference-stmt stmtsep]
                           *((typedef-stmt /
                              grouping-stmt) stmtsep)
                           [input-stmt stmtsep]
                           [output-stmt stmtsep]
                       "}")

input-stmt          = input-keyword optsep
                      "{" stmtsep
                          ;; these stmts can appear in any order
                          *((typedef-stmt /
                             grouping-stmt) stmtsep)
                          1*(data-def-stmt stmtsep)
                      "}"

output-stmt         = output-keyword optsep
                      "{" stmtsep
                          ;; these stmts can appear in any order
                          *((typedef-stmt /
                             grouping-stmt) stmtsep)
                          1*(data-def-stmt stmtsep)
                      "}"
```

<rpc> Message

- Sent by client to server to request an operation

```
<rpc message-id="101"
     xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
    <source>
      <running/>
    </source>
    <filter type="subtree">
      <top xmlns="http://example.com/schema/1.2/config">
        <users>
          <user>
            <name>fred</name>
          </user>
        </users>
      </top>
    </filter>
  </get-config>
</rpc>
```

<rpc-reply> Message

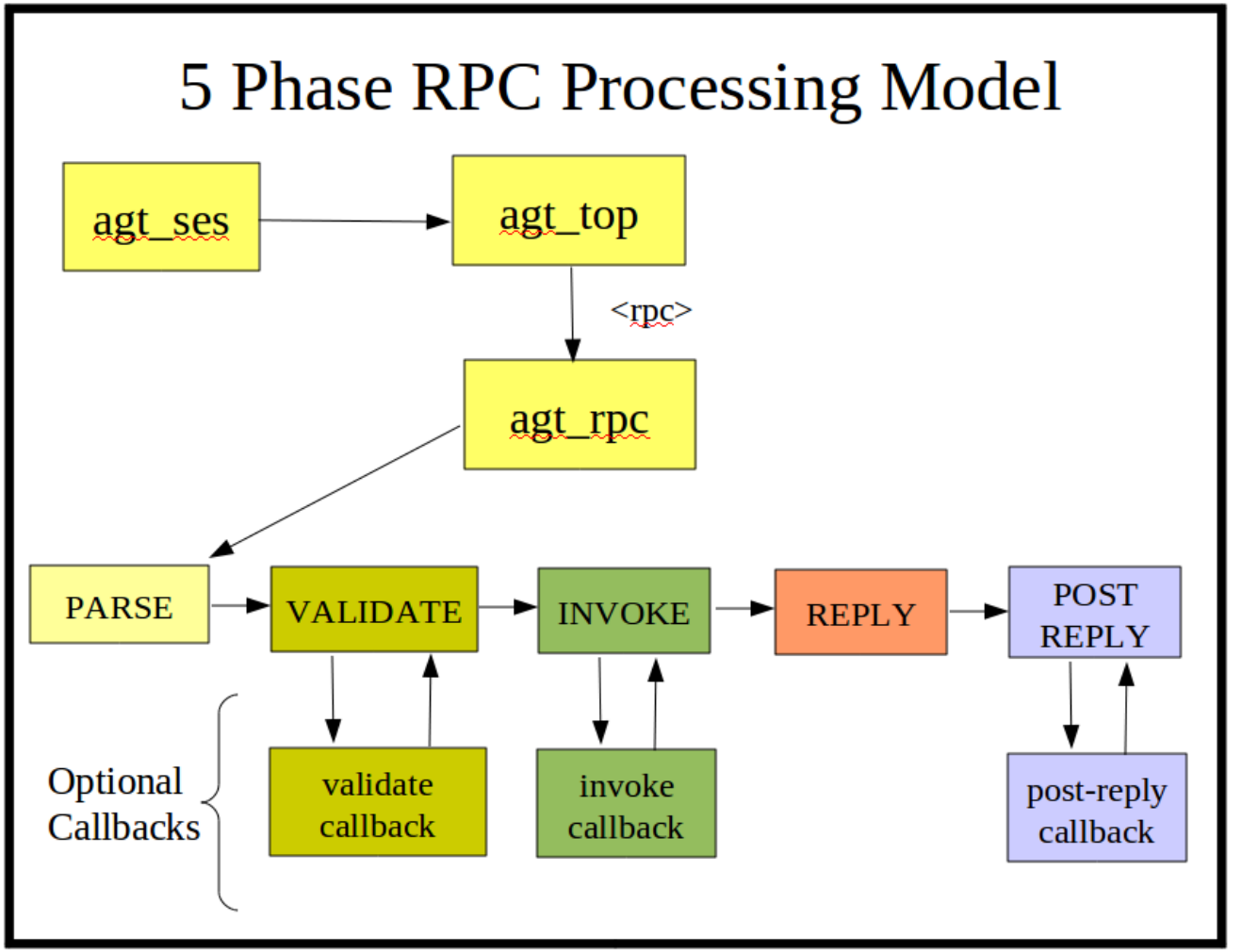
- Sent by the server to the client and contains the status and/or data for the specific RPC request

```
<rpc-reply message-id="101"
     xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
    <top xmlns="http://example.com/schema/1.2/config">
      <users>
        <user>
          <name>fred</name>
          <type>admin</type>
          <full-name>Fred Flintstone</full-name>
          <company-info>
            <dept>2</dept>
            <id>2</id>
          </company-info>
        </user>
      </users>
    </top>
  </data>
</rpc-reply>
```

agt_rpc Module

- init_fn:
  - agt_rpc_register_method
  - agt_rpc_support_method
  - agt_rpc_unsupport_method
- cleanup function:
  - agt_rpc_unregister_method

RPC Callbacks



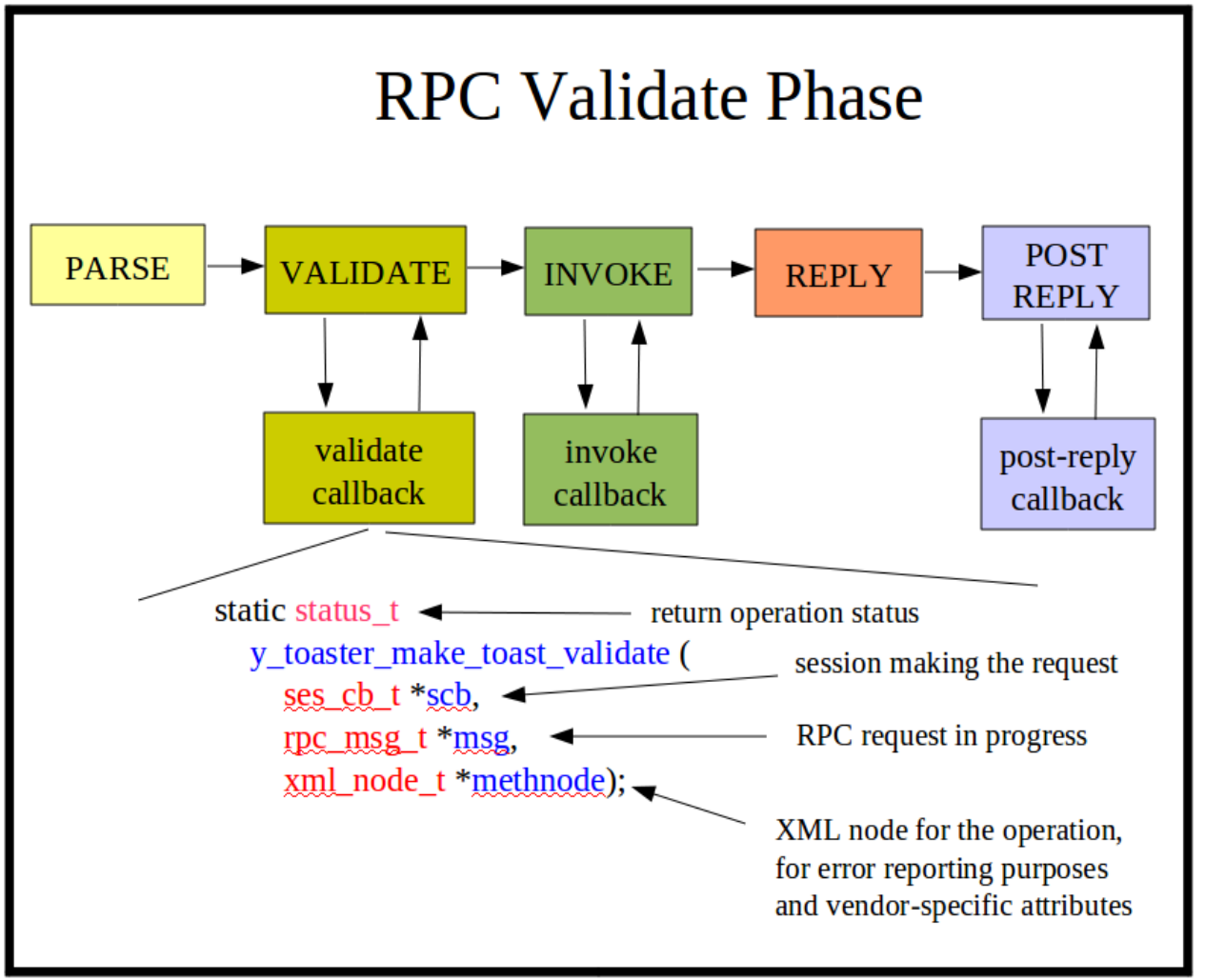
RPC Callback Function

- All phases have same function footprint

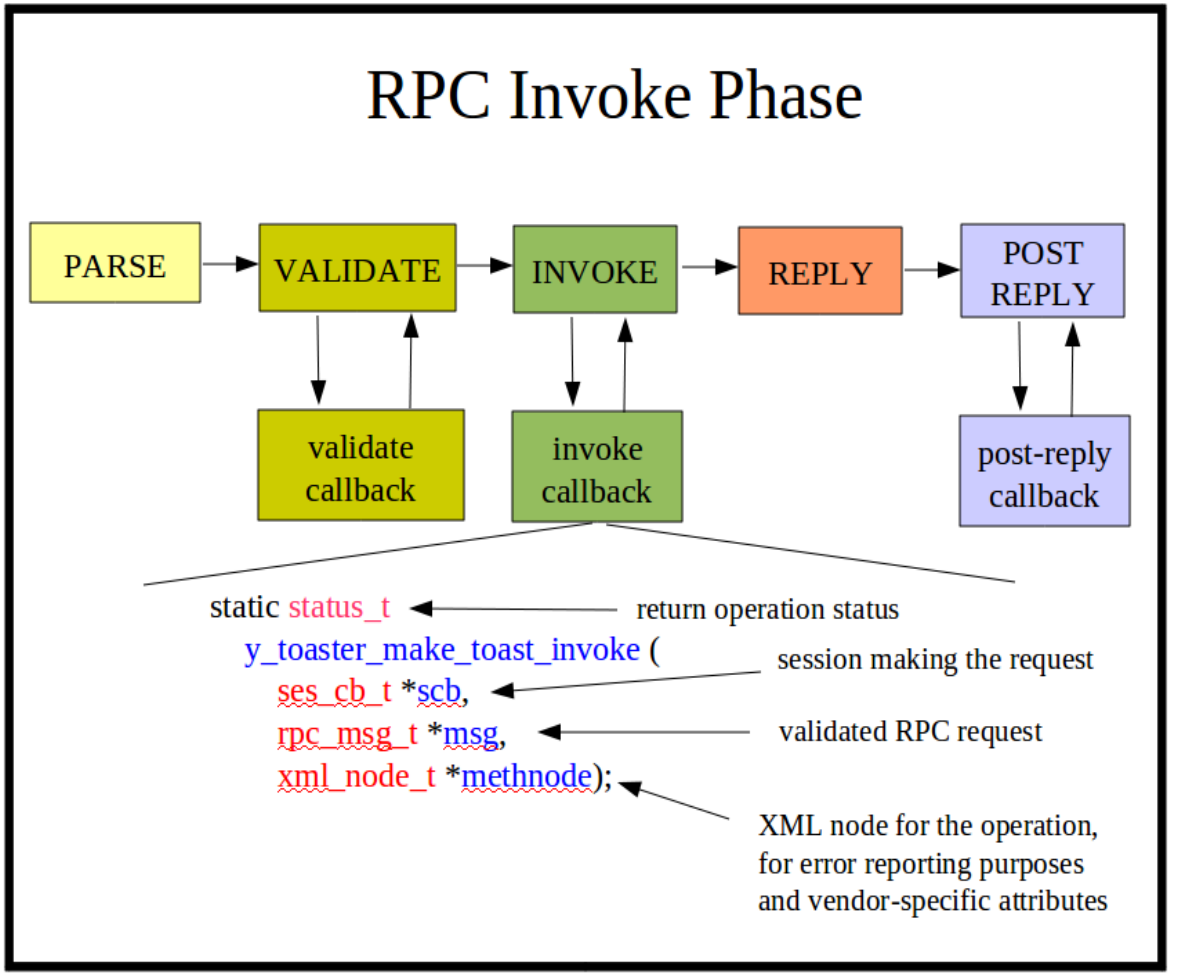
```
/*************************************************************************
* FUNCTION y_ietf_netconf_partial_lock_partial_lock_validate
*
* RPC validation phase
* All YANG constraints have passed at this point.
* Add description-stmt checks in this function.
*
* INPUTS:
*    see agt/agt_rpc.h for details
*
* RETURNS:
*    error status
*************************************************************************/
static status_t
   y_ietf_netconf_partial_lock_partial_lock_validate (
      ses_cb_t *scb,
      rpc_msg_t *msg,
      xml_node_t *methnode)
{
```

Sec. 6.4, RPC Operation Interface

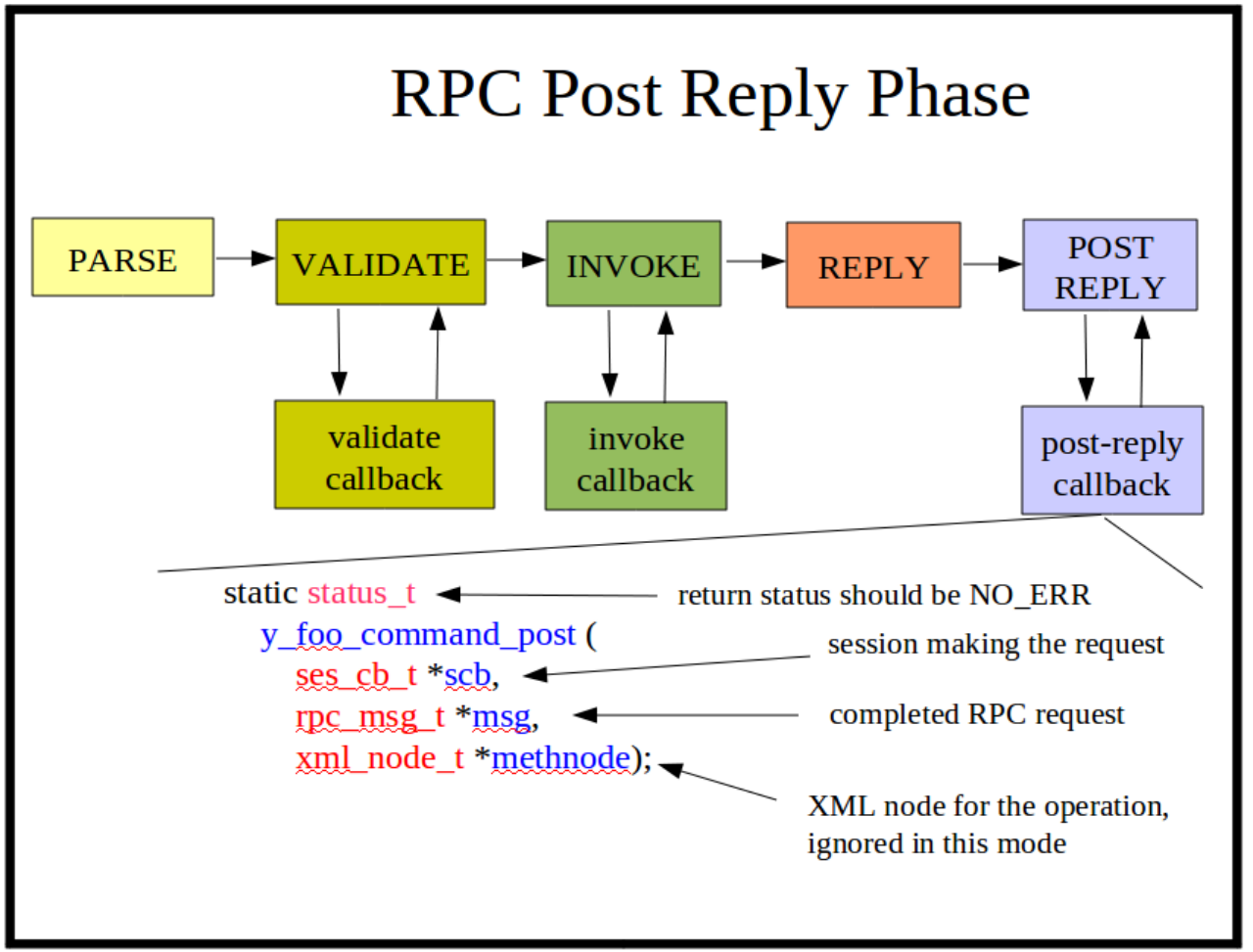
RPC Validate



RPC Invoke



RPC Post Reply



Part 5: Notifications

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Notifications

- YANG “notification” statement defines event name, event namespace, and payload
- NETCONF <notification> message
- SIL “send” function generated for each notification
- Notification “send” functions do not register any callback, since they initiate the event notification
- <create-subscription> operation
- Notification CLI Parameters
- YumaPro notification extensions

YANG notification-stmt

- Notification data-def-stmt used in callback

```
notification-stmt   = notification-keyword sep
                      identifier-arg-str optsep
                      (";" /
                       "{" stmtsep
                           ;; these stmts can appear in any order
                           *(if-feature-stmt stmtsep)
                           [status-stmt stmtsep]
                           [description-stmt stmtsep]
                           [reference-stmt stmtsep]
                           *((typedef-stmt /
                              grouping-stmt) stmtsep)
                           *(data-def-stmt stmtsep)
                       "}")
```

RFC 6020, Sec. 7.14, notification statement

YANG notification-stmt Example

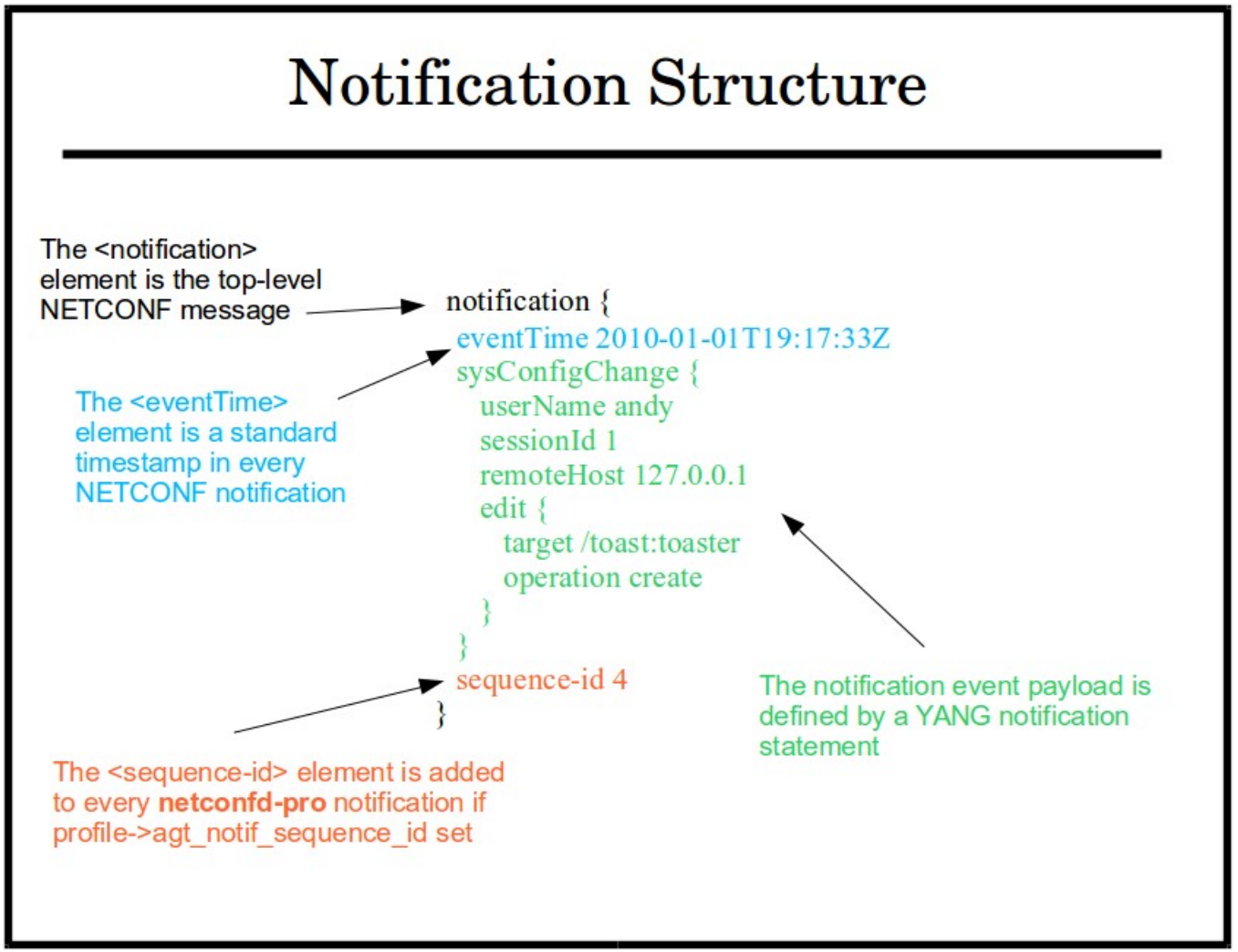
```
notification netconf-capability-change {
  description
    "Generated when the NETCONF server detects that
   the server capabilities have changed.
   Indicates which capabilities have been added, deleted,
   and/or modified.  The manner in which a server
   capability is changed is outside the scope of this
   document.";
  uses changed-by-parms;

  leaf-list added-capability {
    type inet:uri;
    description
      "List of capabilities that have just been added.";
  }

  leaf-list deleted-capability {
    type inet:uri;
    description
      "List of capabilities that have just been deleted.";
  }

  leaf-list modified-capability {
    type inet:uri;
    description
      "List of capabilities that have just been modified.
     A capability is considered to be modified if the
     base URI for the capability has not changed, but
     one or more of the parameters encoded at the end of
     the capability URI have changed.
     The new modified value of the complete URI is returned.";
  }
}  // notification netconf-capability-change
```

<notification> Message



SIL notif_send Function

- Parameters based on the YANG payload
  - Same function for y_ and u_ variants

```
/*************************************************************
* FUNCTION u_ietf_netconf_notifications_netconf_capability_change_send
*
* Send a u_ietf_netconf_notifications_netconf_capability_change notification
* Called by your code when notification event occurs
*
*************************************************************/
void u_ietf_netconf_notifications_netconf_capability_change_send (
    y_ietf_netconf_notifications_T_netconf_capability_change_changed_by *changed_by,
    const xmlChar *added_capability,
    const xmlChar *deleted_capability,
    const xmlChar *modified_capability)
{
```

Developer Sec. 6.6, Notifications

SIL notif_send Tasks

- Check if notifications enabled or exit
- Create a new notification
  - agt_not_new_notification
- Add data to payload
  - agt_not_add_to_payload
- Queue the notification for processing
  - SIL: agt_not_queue_notification
  - SIL-SA: sil_sa_queue_notification

<create-subscription>

- RFC 5277 defines NETCONF notifications
  - 1 subscription per session
  - :interleave capability if commands allowed on the subscription session
  - netconfd-pro never times out a session receiving notifications
  - netconfd-pro always advertises :interleave
- filter parameter (subtree or XPath)
- Replay Support
  - startTime and stopTime parameters allowed

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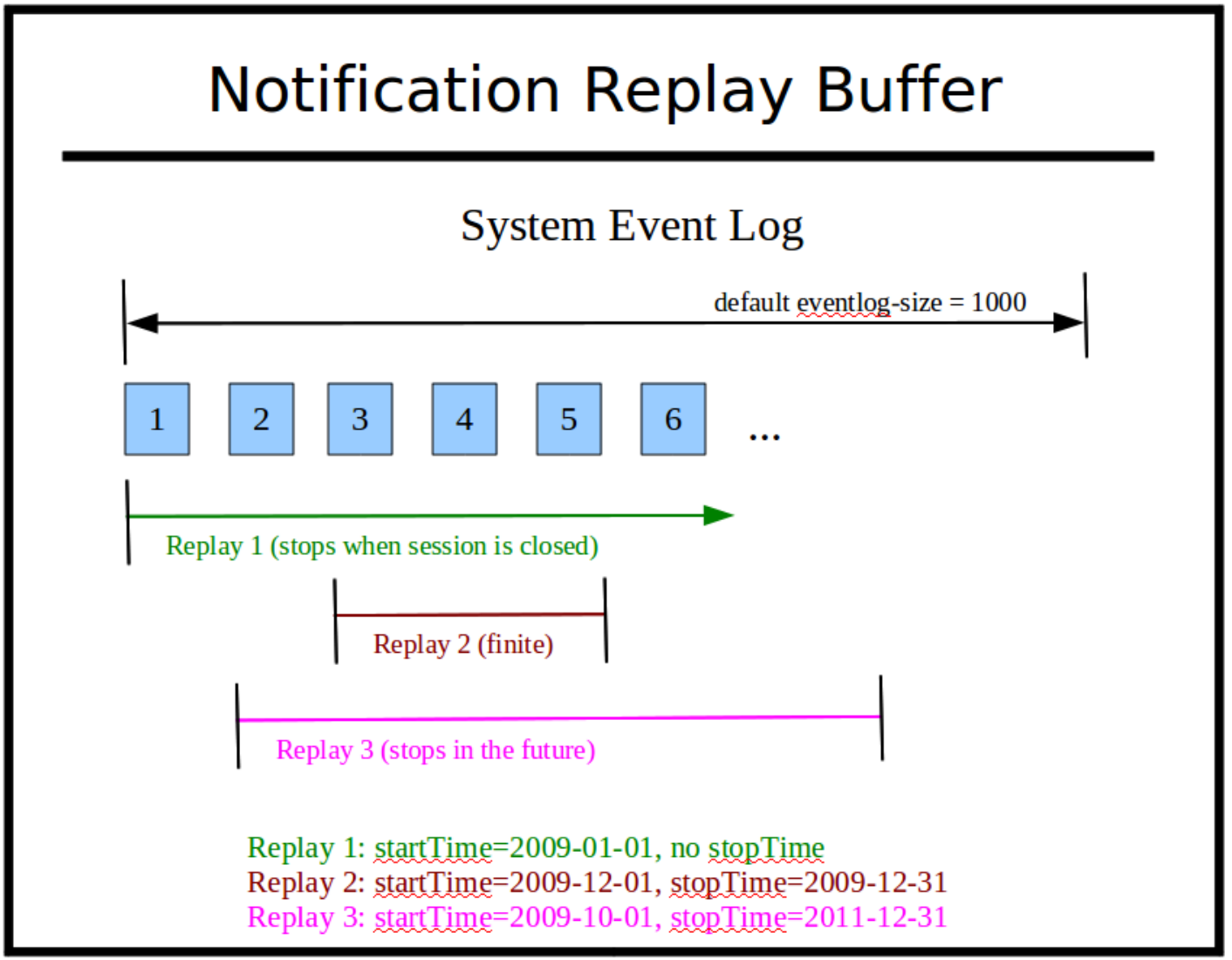
Replay Buffer



Notification CLI Parameters

- --eventlog-size=*number [d: 1000]*
  - replay buffer size
- --max-burst=*number* [d: 10]
  - max notifications to 1 session per second
- --message-indent=*number* [d: -1]
  - affects all server sent messages
- --with-notifications=*boolean* [d: true]
  - used to disable notifications

YumaPro Notification Extensions

- sequence-id:
  - Enabled in server profile at boot-time
  - Adds incremental numeric ID to each notification event
  - Sequence-id is per event generated, not per message sent to all subscription sessions
- yumaworks-event-filter.yang
  - Suppress generation of specific event types
  - <filter> is post-replay buffer
  - <event-filter> is pre-replay buffer
- <cancel-subscription> operation

Part 6: Retrieval Operations

- Intro/Big Picture
- YANG Tutorial
- Getting Started with Server Development
- RPC Processing
- Notifications
- Retrieval Operations
- Transaction Model
- Edit Operations
- Error Handling
- SIL Control
- SIL Debugging

Retrieval Operations

- YANG data definition statement used to specify syntax and semantics of all conceptual data structures on the server
- Configuration Nodes (val_value_t trees)
- 3 ways to implement retrieval callbacks
- Defaults handling
- Entity tags and Last-Modified timestamps
- YumaPro retrieval extensions

YANG data-def-stmt

```
data-def-stmt        = container-stmt /
                       leaf-stmt /
                       leaf-list-stmt /
                       list-stmt /
                       choice-stmt /
                       anyxml-stmt /
                       uses-stmt
```

config-stmt

- config=true (default)
  - configuration datastore contents
  - <get-config>, <edit-config>, etc.
- config=false
  - operational data
  - <get>

3 GET Callback Variants

- 3 different ways to support operational data
  - static get
    - data and value exist in data tree
  - virtual get
    - data exists in data tree but value retrieved via callback
    - callback stored in each virtual node
  - get2
    - no data exists in the data tree
    - callback stored in object schema node

Static GET

- static get
  - Data node exists in the system data tree
  - Value stored in the data node
  - All config=true nodes are currently this type
  - This variant is suitable for operational data that is static, such as the system boot-time

Static GET Registration

- Example GET static implementation
  - Generate the static value
  - Create a static leaf with this value
  - add child to parent

```
/* add /system/sysBootDateTime */
xmlChar tstampbuff[TSTAMP_MIN_SIZE];
tstamp_datetime(tstampbuff);
childval = agt_make_leaf(systemobj,
                         system_N_sysBootDateTime,
                         tstampbuff, &res);
if (childval) {
   val_add_child(childval, topval);
} else {
   return res;
}
```

Virtual GET

- virtual get1
  - Data node exists in the system data tree
  - Value NOT stored in the data node
  - Uses get callback
  - Created with utility functions:
    - val_init_virtual
    - agt_make_virtual_leaf
  - Data retrieval done by server as needed
    - val_get_virtual_value

Virtual GET Registration

- Example Virtual Get Registration
  - create a leaf with a callback
  - add to the parent

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```
/* add /system/sysCurrentDateTime */
childval = agt_make_virtual_leaf(systemobj,
                                 system_N_sysCurrentDateTime,
                                 get_currentDateTime, &res);
if (childval) {
   val_add_child(childval, topval);
} else {
   return res;
}
```

Virtual GET Callback

- Example Virtual Get Callback

```
static status_t
   get_currentDateTime (ses_cb_t *scb,
                        getcb_mode_t cbmode,
                        const val_value_t *virval,
                        val_value_t  *dstval)
{
   (void)scb;
   (void)virval;

   if (cbmode == GETCB_GET_VALUE) {
      xmlChar *buff = (xmlChar *)m__getMem(TSTAMP_MIN_SIZE);
      if (!buff) {
         return ERR_INTERNAL_MEM;
      }
      tstamp_datetime(buff);
      VAL_STR(dstval) = buff;
      return NO_ERR;
   } else {
      return ERR_NCX_OPERATION_NOT_SUPPORTED;
   }

} /* get_currentDateTime */
```

GET2 Variant for Retrieval

- get2
  - Data nodes are not in the system data tree
  - get2 callback registered for container, list, and choice schema nodes
  - Callback returns child terminal nodes, not entire subtree
  - Keys, select nodes, and content match nodes available to callback in getcb_get2_t struct
  - Get, GetNext, and GetBulk modes supported
  - Callback usually returns NO_ERR if data found of ERR_NCX_NO_INSTANCE if the requested data is not found

Callback Tasks for GET2

- non-presence (NP) container
  - return requested child nodes
- presence (P) container
  - check if container exists
  - returned requested child nodes
- choice
  - return active-case name (if any)
  - return requested child nodes
- list
  - get requested instance(s), add return keys
  - return requested child nodes

GET2 Registration

- 1 Callback registered per complex object


```
res = agt_cb_register_get_callback(
    y_ietf_interfaces_M_ietf_interfaces,
    (const xmlChar *)"/if:interfaces-state",
    y_ietf_interfaces_R_ietf_interfaces,
    ietf_interfaces_interfaces_state_get);
if (res != NO_ERR) {
    return res;
}

res = agt_cb_register_get_callback(
    y_ietf_interfaces_M_ietf_interfaces,
    (const xmlChar *)"/if:interfaces-state/if:interface",
    y_ietf_interfaces_R_ietf_interfaces,
    ietf_interfaces_interfaces_state_interface_get);
if (res != NO_ERR) {
    return res;
}
```

y_ GET2 Callback

- YumaPro GET2 Callback is always the same

```
/*************************************************************************
* FUNCTION ietf_interfaces_interfaces_state_interface_statistics_get
*
* Get database object callback for container statistics
* Path: /interfaces-state/interface/statistics
* Fill in 'get2cb' response fields
*
* INPUTS:
*    see ncx/getcb.h for details (getcb_fn2_t)
*
* RETURNS:
*    error status
*************************************************************************/
static status_t ietf_interfaces_interfaces_state_interface_statistics_get (
   ses_cb_t *scb,
   xml_msg_hdr_t *msg,
   getcb_get2_t *get2cb)
{
```

u_ GET2 Callback

- User GET2 callback parameters include the get2cb and any ancestor keys

```
/*************************************************************************
* FUNCTION u_ietf_interfaces_interfaces_state_interface_statistics_get
*
* Get database object callback for container statistics
* Path: /interfaces-state/interface/statistics
* Fill in 'get2cb' response fields
*
* INPUTS:
*    see ncx/getcb.h for details (getcb_fn2_t)
*
* RETURNS:
*    error status
*************************************************************************/
status_t u_ietf_interfaces_interfaces_state_interface_statistics_get (
   getcb_get2_t *get2cb,
   const xmlChar *k_interfaces_state_interface_name)
{
```

GET2 Callback
GET or GETNEXT Mode

- For container or choice, only GET allowed

```
/* check the callback mode type */
getcb_mode_t cbmode = GETCB_GET2_CBMODE(get2cb);
switch (cbmode) {
case GETCB_GET_VALUE:
   break;
case GETCB_GETNEXT_VALUE:
   return ERR_NCX_NO_INSTANCE;
default:
   return SET_ERROR(ERR_INTERNAL_VAL);
}
```

- For list, GET or GETNEXT is allowed

```
boolean getnext = FALSE;

/* check the callback mode type */
getcb_mode_t cbmode = GETCB_GET2_CBMODE(get2cb);
switch (cbmode) {
case GETCB_GET_VALUE:
   break;
case GETCB_GETNEXT_VALUE:
   getnext = TRUE;
   break;
default:
   return SET_ERROR(ERR_INTERNAL_VAL);
}
```

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GET2 Callback Match Test

- Optional subtree filter content-match test for non-key child terminal nodes
  - only return instance (e.g. row) if the children matching the specified content-match nodes exist with the same values

```
/* optional: check if any content-match nodes are present */
boolean match_test_done = FALSE;
val_value_t *match_val = GETCB_GET2_FIRST_MATCH(get2cb);
for (; match_val; match_val =
   GETCB_GET2_NEXT_MATCH(get2cb, match_val)) {

   /**** CHECK CONTENT NODES AGAINST THIS ENTRY ***/

}
GETCB_GET2_MATCH_TEST_DONE(get2cb) = match_test_done;
```

GET2 Callback List Keys

- List keys passed from y_get to u_get in triplet
  - value, fixed-flag, present-flag

```
/*************************************************************************
* FUNCTION u_ietf_interfaces_interfaces_state_interface_get
*
* Get database object callback for list interface
* Path: /interfaces-state/interface
* Fill in 'get2cb' response fields
*
* INPUTS:
*    see ncx/getcb.h for details (getcb_fn2_t)
*
* RETURNS:
*    error status
*************************************************************************/
status_t u_ietf_interfaces_interfaces_state_interface_get (
   getcb_get2_t *get2cb,
   const xmlChar *k_interfaces_state_interface_name,
   boolean name_fixed,
   boolean name_present)
{
```

GET2 Callback
List Key fixed-flag

- If set for a key then do not increment for GETNEXT
  - E.g., 'name' key would be set for this request


```
<filter type="subtree">
  <top xmlns="http://example.com/schema/1.2/config">
    <users>
      <user>
        <name>fred</name>
      </user>
    </users>
  </top>
</filter>
```

GET2 Callback
List Key present-flag

- If false for a key then return the first entry
- The first request for a list may be a GET with no keys
  - Return the first instance
- E.g., a request for an entire list:

```
<filter type="subtree">
  <top xmlns="http://example.com/schema/1.2/config">
    <users/>
  </top>
</filter>
```

GET2 Callback
List Key return keys

- The key leafs for each entry are returned by the GET2 callback
  - No auto-generated code to handle finding next instance to return

```
/* for GET, make sure all local keys present */
if (!getnext && !name_present) {
   return ERR_NCX_NO_INSTANCE;
}

/* For GET, find the entry that matches the key values
 * For GETNEXT, find the entry that matches the next key value
 * If the 'present' flag is false then return first key instance
 * If the 'fixed' flag is true then no GETNEXT advance for the key
 * Create a new return key val_value_t, then getcb_add_return_key */

/***** ADD RETURN KEYS AND REMOVE THIS COMMENT ****/

if (GETCB_GET2_FIRST_RETURN_KEY(get2cb) == NULL) {
   return ERR_NCX_NO_INSTANCE;
}
```

GET2 Callback More Data

- The more_data flag is set by list callbacks
  - Better to return 'true' if not sure


```
/* For GETNEXT, set the more_data flag true if not sure */
boolean more_data = (getnext) ? TRUE : FALSE;

/**** SET more_data FLAG ****/

GETCB_GET2_MORE_DATA(get2cb) = more_data;
```

GET2 Callback Requested Nodes

- Only applies if there are child terminal nodes

```
/* go through all the requested terminal child objects */
obj_template_t *childobj =
   getcb_first_requested_child(get2cb, obj);
for (; childobj; childobj =
   getcb_next_requested_child(get2cb, childobj)) {

   /* Retrieve the value of this terminal node and
    * add with getcb_add_return_val */

   /* leaf type (identityref) */

   /* leaf admin-status (enumeration) */

   /* leaf oper-status (enumeration) */

   /* leaf last-change (string) */
```

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GET2 SIL Code Exercise

- Examine u_ietf-interfaces.c
- Add code to find interface instances
- Add code to retrieve interface counters
- Build and load SIL library
- Test counter retrieval

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Part 7: Transaction Model

- Intro/Big Picture
- YANG Tutorial
- Getting Started with Server Development
- RPC Processing
- Notifications
- Retrieval Operations
- Transaction Model
- Edit Operations
- Error Handling
- SIL Control
- SIL Debugging

Transaction Model

- Datastores
- Multiple Transaction Variants
- Datastore Locking
- Confirmed Commit Procedure

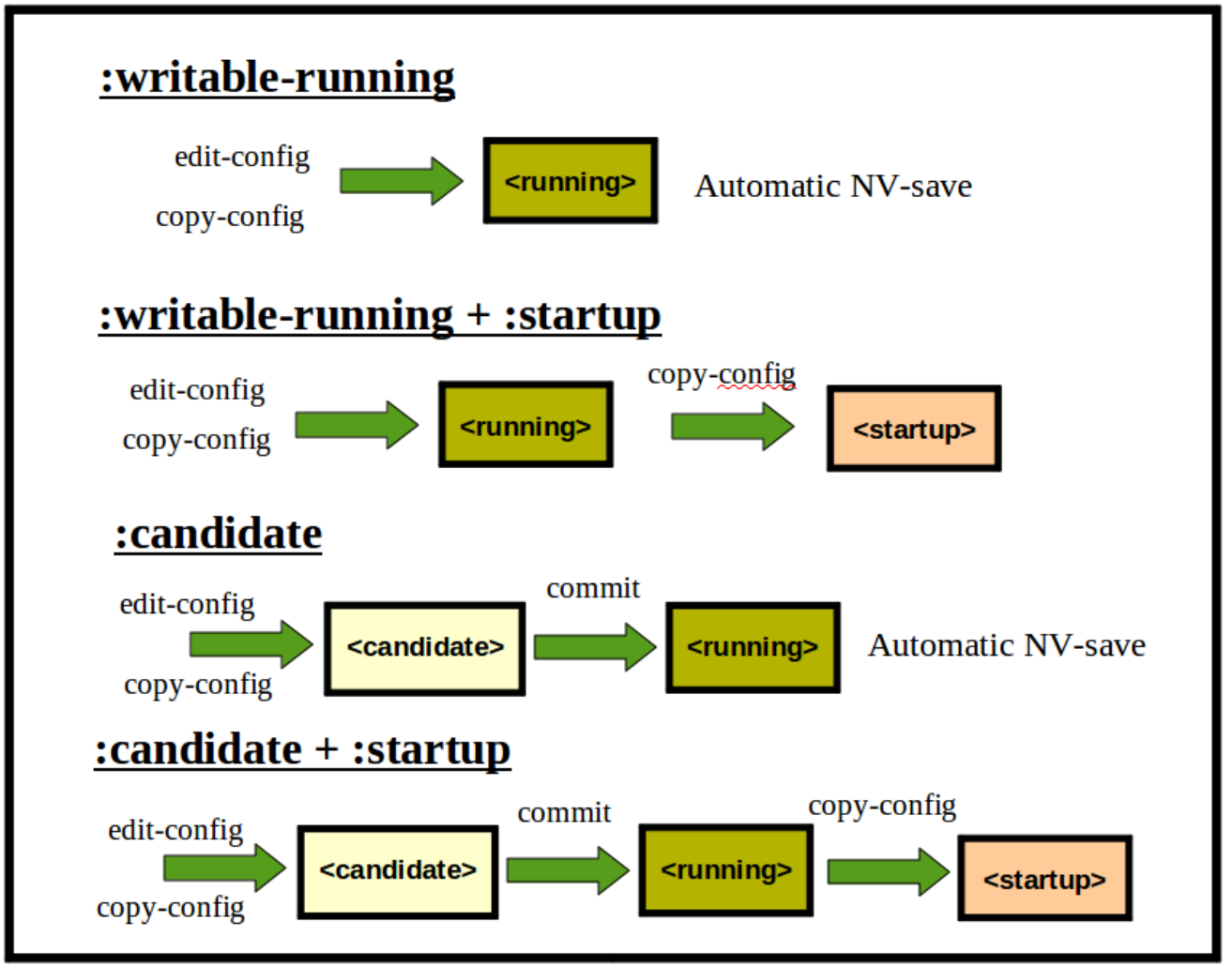
What is a Datastore?

- A Datastore is not a Database
- A conceptual collection of top-level YANG data nodes
  - All datastores share the same schema set
    - Not all protocols access all datastores
  - All data instances in the datastore share some common properties
- Current NETCONF datastores contain only config=true data nodes

3 Standard Datastores

- running (mandatory)
  - represents current intended configuration
- candidate (optional :candidate capability)
  - represents pending edits, not yet applied to running
  - <discard-changes> to clear candidate of edits
  - <commit> to apply all the edits to running
    - mandatory all-or-none commit
- startup (optional :startup capability)
  - represents read-only intended configuration for the next reboot

Transaction Variants



Transaction Variants CLI Options

:writable-running

--target=running
--with-startup=false

:writable-running + :startup

--target=running
--with-startup=true

:candidate

--target=candidate
--with-startup=false

:candidate + :startup

--target=candidate
--with-startup=true

Datastore Locking

- Global <lock> and <unlock>
  - 1 datastore at a time
  - need to lock all datastores
  - Automatic lock release if session for lock-owner terminates for any reason

```
A lock MUST NOT be granted if any of the following conditions is
true:

*  A lock is already held by any NETCONF session or another
   entity.

*  The target configuration is <candidate>, it has already been
   modified, and these changes have not been committed or rolled
   back.

*  The target configuration is <running>, and another NETCONF
   session has an ongoing confirmed commit (Section 8.4).
```

Confirmed Commit

- <confirmed/> parameter in <commit> operation makes it a confirmed commit
  - 2nd <commit> required or server will rollback commit after timeout
  - Client can also send <cancel-commit> before the timeout
  - No warning to other clients rollback is pending
  - Client should use “persist-id” parameter to lock out other edits without explicit locks

RFC 6241, Sec. 8.4, Confirmed Commit

Confirmed Commit Exercise

- Lock datastores (!)
- Create an interface
- Confirmed commit w/ short timeout and persist-id
- Wait for timeout
- Observe rollback
- Redo but confirm the commit this time

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Automating the Internet

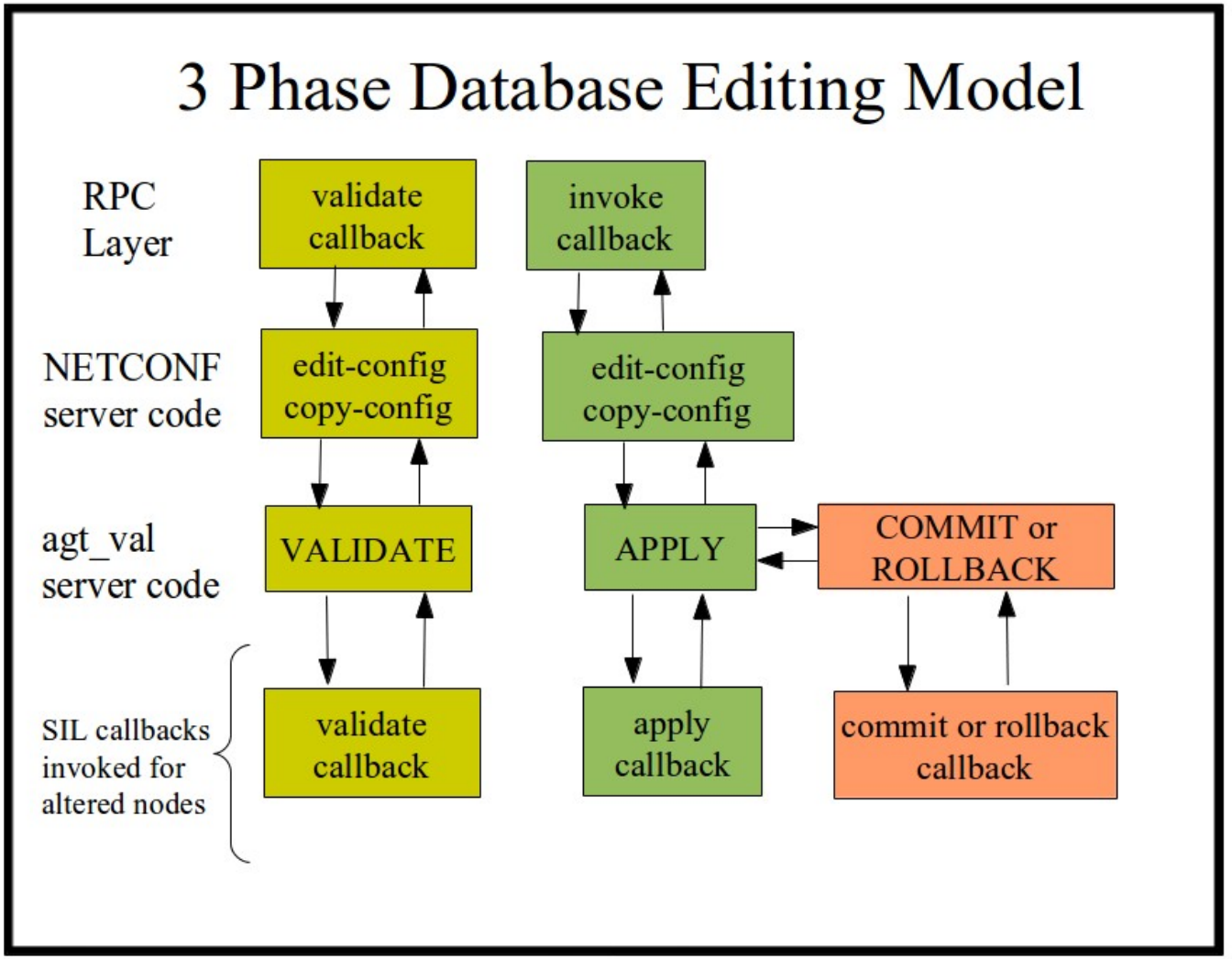
Part 8: Edit Operations

- Intro/Big Picture
- YANG Tutorial
- Getting Started with Server Development
- RPC Processing
- Notifications
- Retrieval Operations
- Transaction Model
- Edit Operations
- Error Handling
- SIL Control
- SIL Debugging

Edit Operations

- 3 Phase Callback Model
- Leaf-based (edit1) vs. List-based (edit2)
- Rollback
- Nested Edits
- LOAD Callback Mode
- Configuration Replay

3 Phase Edit Callbacks



Edit1 Callbacks

- First Generation Edit Callbacks
  - SIL callback generated for every node (except key leafs)
  - If leaf callbacks deleted then parent container or list called N times for each leaf edited in the same request

Edit2 Callbacks

- Second Generation Edit Callbacks
  - SIL callback generated only for list, container, and choice statements
  - Parent container or list called only once for all terminal nodes edited in the same edit
    - terminal = leaf, leaf-list, anyxml
-

Rollback

- An error in the “validate” phase will not produce a rollback callback
- An error in the “apply” phase will produce a rollback callback
  - There will not be any commit callbacks
  - Some SIL callbacks may not get “apply” callback
- An error in the “commit” phase will produce a rollback callback
  - If commit already done for that node, then “reverse-edit” is done instead

Reverse Edit

- If commit already done for a data node and transaction is being rolled back
  - new transaction created that reverses the edit that was just committed
- New validate, apply, and commit callbacks will be done for the reverse edit

LOAD Callback Mode

- editop = OP_EDITOP_LOAD
  - Used during load from startup-cfg to running
  - Also used during configuration replay
  - Used by server to optimize validation and datastore processing
  - SIL can use this info if desired
    - same as OP_EDITOP_CREATE

Configuration Replay

- Used to resynch the main server or subsystems
  - SIL requests replay with agt_trigger_replay()
  - SIL-SA requests replay by sending a <trigger-replay> event message
- If main server not affected, then config replay is only done for subsystem(s)
  - e.g., subsystem reboots and requests replay
- No edits are recorded (or data changed)
  - Only the SIL callbacks are re-done

Developer Sec. 6.2, Configuration Replay

Edit2 Exercise

- Step through code to create and interface
  - Validate callback
  - Apply callback
  - Commit callback

YumaWorks
Automating the Internet

Part 9: Error Handling

- Intro/Big Picture
- YANG Tutorial
- Getting Started with Server Development
- RPC Processing
- Notifications
- Retrieval Operations
- Transaction Model
- Edit Operations
- Error Handling
- SIL Control
- SIL Debugging

Error Handling

- <rpc-error> Element
- SET_ERROR for programming erors
- agt_record_error (and variants) for user errors
- rpc_msg_add_error_data

<rpc-error>

- <rpc-reply> message contains 1 or more <rpc-error> elements if the operation failed

```
<rpc-reply message-id="101"
     xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <rpc-error> <!-- lock failed -->
    <error-type>protocol</error-type>
    <error-tag>lock-denied</error-tag>
    <error-severity>error</error-severity>
    <error-message>
      Lock failed, lock is already held
    </error-message>
    <error-info>
      <session-id>454</session-id>
      <!-- lock is held by NETCONF session 454 -->
    </error-info>
  </rpc-error>
</rpc-reply>
```

RFC 6241 Sec. 4.3, <rpc-error> Element

SET_ERROR

- This macro is for flagging programming errors
  - Do not use for normal user errors
  - E.g., an unsupported or unexpected value is used in a switch statement

```
switch (editop) {
case OP_EDITOP_LOAD:
   break;
case OP_EDITOP_MERGE:
   break;
case OP_EDITOP_REPLACE:
   break;
case OP_EDITOP_CREATE:
   break;
case OP_EDITOP_DELETE:
   break;
default:
   res = SET_ERROR(ERR_INTERNAL_VAL);
}
```

agt_record_error

- Main error reporting API in the server

```
void
   agt_record_error (ses_cb_t *scb,
                     xml_msg_hdr_t *msghdr,
                     ncx_layer_t layer,
                     status_t  res,
                     const xml_node_t *xmlnode,
                     ncx_node_t parmtyp,
                     const void *error_info,
                     ncx_node_t nodetyp,
                     void *error_path)
{
```

Developer Sec. 6.3.3, agt_record_error

agt_record_error Parameters

Parameter	Description
scb	Session processing the request
msghdr	Message header used to store error record
layer	Conceptual protocol layer for the error
res	internal status code for the error
xmlnode	XML node being parsed (may be NULL if N/A)
parmtyp	type of data structure pointed at by errorinfo
errorinfo	data to use for the <error-info> field
nodetyp	type of data structure pointed at by error_path
error_path	data to use fot the <error-path> field

agt_record_error_errinfo

- Same as agt_record_error, plus custom errinfo

```
void
   agt_record_error_errinfo (ses_cb_t *scb,
                             xml_msg_hdr_t *msghdr,
                             ncx_layer_t layer,
                             status_t  res,
                             const xml_node_t *xmlnode,
                             ncx_node_t parmtyp,
                             const void *error_info,
                             ncx_node_t nodetyp,
                             void *error_path,
                             const ncx_errinfo_t *errinfo)
{
```

Developer, Sec. 6.3.4, agt_record_error_errinfo

ncx_errinfo_t

- Struct used to provide custom values for some <rpc-error> fields
  - error-app-tag
  - error-message

```
/* YANG error info statement struct */
typedef struct ncx_errinfo_t_ {
    dlq_hdr_t       qhdr;
    xmlChar         *descr;
    xmlChar         *ref;
    xmlChar         *error_app_tag;
    xmlChar         *error_message;
    boolean         seen;               /* for yangdiff */
} ncx_errinfo_t;
```

rpc_msg_add_error_data

- Used to add custom data to the <error-info> container within the <rpc-error> element

```
/* a real add_user_data callback would probably get a system
 * value instead of a constant; use constant here
 */
const xmlChar *valuebuff = (const xmlChar *)"42";

status_t res = NO_ERR;
val_value_t *testdata_val =
   val_make_simval_obj(testdata_obj, valuebuff, &res);

if (testdata_val) {
   rpc_msg_add_error_data(msg, testdata_val);
}
```

Developer Sec. 6.3.5, Adding <error-info>

Part 10: SIL Control

- Intro/Big Picture
- YANG Tutorial
- Getting Started with Server Development
- RPC Processing
- Notifications
- Retrieval Operations
- Transaction Model
- Edit Operations
- Error Handling
- SIL Control
- SIL Debugging

SIL Control

- yp-system library
- agt_util support functions
- val support functions and macros
- val_util support functions
- YANG extensions that affect SIL processing
- CLI parameters that affect SIL processing

yp-system Library

- System callbacks not related to a YANG module
  - API callbacks
    - yp_system_init_profile
    - yp_system_init1
    - yp_system_init2
    - yp_system_cleanup
  - Optional Vendor APIs
    - External Access Control Model
    - External Syslog
  - Additional Server Processing Hooks

YumaPro yp-system API Guide

yp-system Library Extra Hooks

- System events that can have callbacks invoked
  - candidate reload
  - module load
  - module unload
  - commit complete
  - external NV-load handler
  - external NV-save handler
  - config-replay requested

yp-system, sec. 7, System Callback Functions

agt_util

- Error handling
  - agt_record_error
  - agt_record_error_errinfo
  - agt_record_attr_error
  - agt_record_unique_error
- agt_tree Filtering
  - agt_check_default
  - agt_check_config_false
  - agt_check_save

agt_util (2)

- Make return val_value_t subtrees
  - agt_make_leaf
  - agt_make_uint_leaf
  - agt_make_int_leaf
  - agt_make_uint64_leaf
  - agt_make_int64_leaf
  - agt_make_idref_leaf
  - agt_make_list
  - agt_make_object
  - agt_make_virtual_leaf

agt_util (3)

- Add datastore nodes
  - agt_add_top_virtual
  - agt_add_top_container
  - agt_add_container
  - agt_add_top_node_if_missing
  - agt_make_leaf2
  - agt_make_union_leaf
  - agt_make_uint_leaf2
  - agt_make_int_leaf2
  - agt_make_bits_leaf

/usr/include/yumapro/agt/agt_util.h

val

- val_value_t support
  - val_new_value
  - val_init_from_template
  - val_free_value
  - VAL_INT() and other macros to access value
  - VAL_TYPE(), VAL_NAME() macros
  - val_simval_ok and other validation functions
  - val_dump_value
  - val_sprintf_simval_nc

/usr/include/yumapro/ncx/val.h

val

- val_value_t support
  - val_new_value
  - val_init_from_template
  - val_free_value
  - VAL_INT() and other macros to access value
  - VAL_TYPE(), VAL_NAME() macros
  - val_simval_ok and other validation functions
  - val_dump_value
  - val_sprintf_simval_nc

/usr/include/yumapro/ncx/val.h

val_util

- Additional val_value_t support
  - val_make_simval_obj
  - val_gen_index_chain
  - val_set_canonical_order
  - val_add_defaults
  - val_instance_check
  - val_get_choice_first_set
  - val_get_choice_next_set
  - val_choice_is_set

/usr/include/yumapro/ncx/val_util.h

YANG Extensions for SIL

- nacm:default-deny-all
  - Deny all access unless explicit NACM rules
- nacm:default-deny-write
  - Deny all writes unless explicit NACM rules
- ypx:exclusive-rpc
  - Do not allow concurrent calls to the RPC
- ncx:sil-delete-children-first
  - Force child callbacks if parent deleted
- ywx:sil-force-replace-replay
  - Force replay of unchanged siblings for replace

YANG Extensions for SIL (2)

- ywx:sil-force-replay
  - Force replay of unchanged siblings for merge
- ywx:sil-priority
  - Force SIL callback order for edits
- ywx:user-write
  - Control user write access
    - override YANG config=true

Developer Sec. 12.2, Built-in Language Extension

CLI Parameters for SIL

Parameter	Description
--bundle	Load a SIL or SIL-SA bundle library
--default-style	Set the system definition of a default leaf
--deviation	Load a YANG module for its deviations only
--feature-disable	Disable a YANG feature
--feature-enable	Enable a YANG feature
--feature-enable-default	Set YANG features default enabled or not
--log	Set the log file
--log-level	Set logging debug level

CLI Parameters for SIL (2)

Parameter	Description
--no-watcher	Do not start YPWatcher process
--running-error	Allow running datastore to container validation errors
--runpath	Directory paths to search for libraries
--sil-missing-error	Force an error if SIL or SIL-SA library not found during module load
--sil-skip-load	Skip all OP_EDITOP_LOAD mode callbacks

netconfd-pro, Sec. 3, CLI Reference

Part 11: SIL Debugging

- Intro/Big Picture
- YANG Tutorial
- Getting Started with Server Development
- RPC Processing
- Notifications
- Retrieval Operations
- Transaction Model
- Edit Operations
- Error Handling
- SIL Control
- SIL Debugging

SIL Debugging

- Logging
- Using yangcli-pro to test the server
- sil-error
- sil-sa-app
- db-api-app

Logging

Parameter	Description
log-level	Set the debug output level
log	Set the log file
log-append	Append or overwrite existing log file
log-mirror	Copy log output to STDOUT and log file
log-header	Set custom logging header
log-syslog	Send logging output to SYSLOG
log-backtrace	Add stack backtrace info to log output
log-backtrace-level	Set minimum logging level to add backtrace
log-event-drops	Log notification event drop information
log-pthread-level	Add PTHREAD specific logging information

YumaWorks
Automating the Internet

Using yangcli-pro

- NETCONF Client Test Tool
  - variables
    - $$foo = command
    - @foo.xml = command
    - command parm=$foo
    - command parm=@foo.xml
  - scripts
    - Just text files with yangcli commands
  - test suites
    - Positive and negative response testing

YumaPro yangcli-pro Manual

sil-error

- Special YANG module used to force an error during transaction processing
  - set 'sil-phase' to arm test
  - set 'sil-trigger' to any value to trigger error

```
grouping sil-error-test {
  leaf sil-phase {
    type sil-error-phase;
    description
      "Set this to the SIL callback phase you want to cause an
       operation-failed error to occur.";
  }
  leaf sil-trigger {
    type uint32;
    description
      "Set this object to trigger an operation-failed error
       if the sil-error-phase is not set to 'none'.";
  }
```

sil-error (2)

- YANG objects that support the sil-error objects
  - root, container, list, and choice

```
+--rw sil-phase?        sil-error-phase
+--rw sil-trigger?      uint32
+--rw sil-error-con
|  +--rw sil-phase?     sil-error-phase
|  +--rw sil-trigger?   uint32
+--rw sil-error-list* [id]
|  +--rw id             string
|  +--rw sil-phase?     sil-error-phase
|  +--rw sil-trigger?   uint32
+--rw sil-error-con2
   +--rw (sil-error-choice)?
      +--:(dummy)
      |  +--rw dummy?         int8
      +--:(real)
         +--rw sil-phase?     sil-error-phase
         +--rw sil-trigger?   uint32
```

sil-sa-app

- sil-sa-app is a dummy application to run SIL-SA library code
  - No special configuration needed
  - If SIL-SA library found by subsystem for configured module or bundle, then it is loaded and registered with main server
- Start main server, then run sil-sa-app
  - sil-sa-app [log-level=*enum*] [subsys-id=*id]*

db-api-app

- db-api-app is a dummy application to send a DB-API edit from a subsystem to the main server
  - DB-API used when server has an external database (e.g. CLI) and edits are initiated from the system as well as NETCONF
- Hard-wired to send 1 edit request
  - Need to edit main.c to change the edit that is sent
  - Used to demonstrate db_api_send_edit API

Thank You!