Beyond Cool Dashboards and Fancy Visualizations

Splunk as a full stack application development platform

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Forward-Looking Statements

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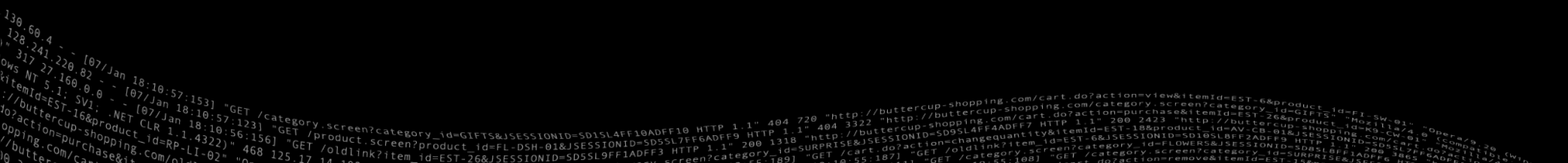
Agenda

- Qmulos Background
- Splunk Apps for Compliance and Auditing Automation
  - Q-Compliance
  - Q-Audit
- Features and Functionality of Q-Compliance
- Anatomy of an Enterprise Web Application
- Implementing each Subsystem/Component in Splunk
- Comparison with Building from Scratch/Open Source
- Key Takeaways
- Links to Useful Resources



Who Are We?

- Tieu Luu
- VP Product Development, Qmulos
  - 20+ years software development in government, enterprise IT, and startups
  - Last ten years focused on building cyber security analytics and continuous monitoring solutions for large enterprises
- tieu@qmulos.com
- @TechTieu

- Daniel Letchev
- Senior Software Developer, Qmulos
  - Develops Splunk apps @Qmulos that automate cyber security compliance and continuous monitoring
  - Prior to Qmulos, developed DoD's enterprise continuous monitoring solution that monitored the security posture of millions of devices across the DoD's networks
- daniel@qmulos.com

Qmulos Company Overview

Company

- Founded 2012 by DHS Exec responsible for .GOV Cybersecurity Automation
- Decades of proven IT compliance and cyber experience
- SDVOSB, TS facility clearance, 95% cleared staff, located in NoVa
- Reseller, PS, & ISV Splunk Partner

Products

- **Q-Audit**
  - ICS 500-27
  - Insider Threat
- **Q-Compliance**
  - NIST & Custom Controls
  - Various Frameworks
- Built as Premium Apps for the Splunk Platform
- Enables massive scale while automating security and compliance activities

Customers

- Includes small, medium, and large organizations
- Fortune 1000, Federal Civilian, DoD, & Intel Community customers
- **Focused on compliance automation to deliver operational security**

Government Innovation Awards

2018 Inc. 5000 LIST

Qmulos Splunk Apps

Cyber security compliance automation and auditing on the Splunk platform

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Q-Compliance

Visualizations

Analytics

Data Models

Q-Audit

Visualizations

Analytics

Data Models

HR systems
Training/ Learning management systems

Project planning/ management tools

Source code repositories
Code scanners

Agile lifecycle management tools
Automated testing tools

HVAC
Environmental sensors

Trouble ticketing systems

Incident management/ reporting systems

Operating systems
System logs

Asset management systems

Firewalls
Switches

CMDBs
Email filters/gateways

Data loss prevention systems

Storage systems
Backup solutions

Disaster recovery tools

Identity and access management solutions

Network IDS/NIPS
Host IDS/IPS

Perimeter defense solutions

Vulnerability/ threat intelligence tools

Endpoint protection tools

Vulnerability scanners

Patch management systems

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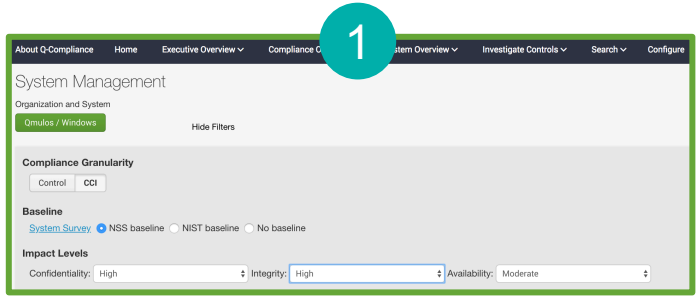
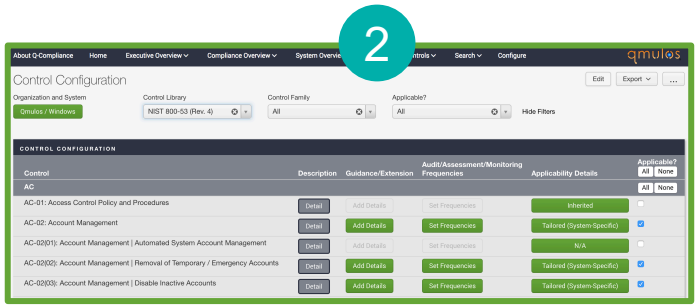
Q-Compliance – Workflow & Functionality





Categorize System

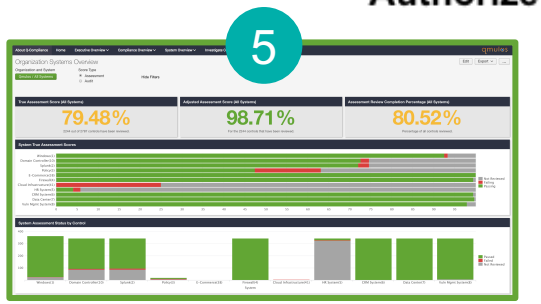
Monitor Controls

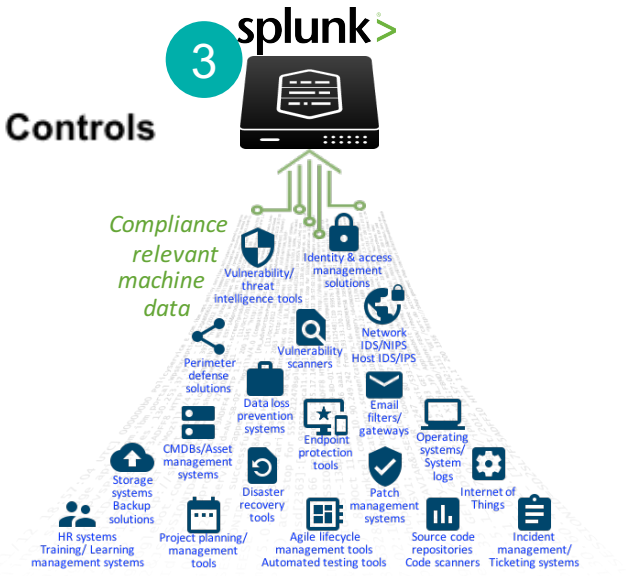
Select Controls

Authorize System

Implement Controls

Assess Controls





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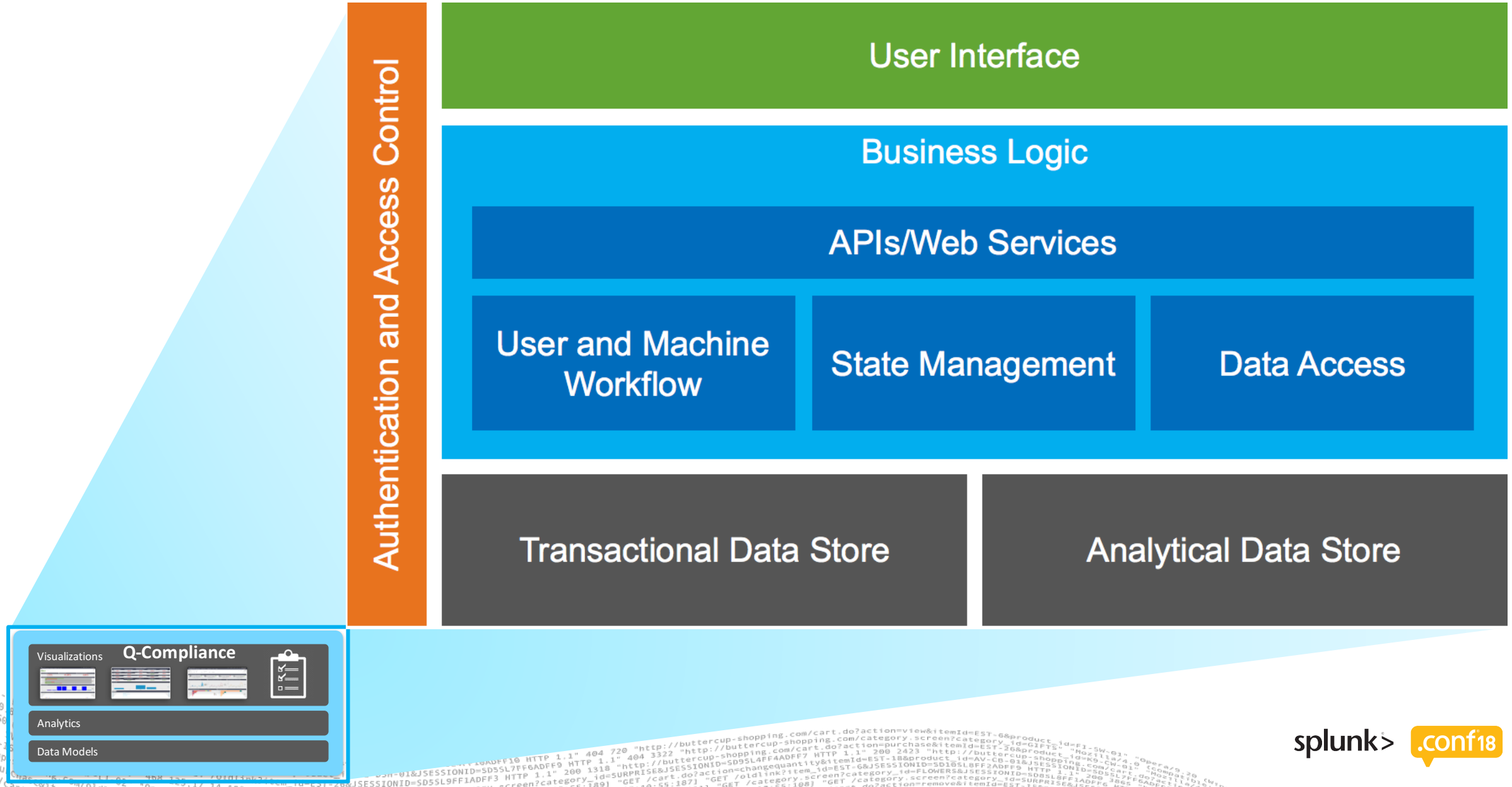
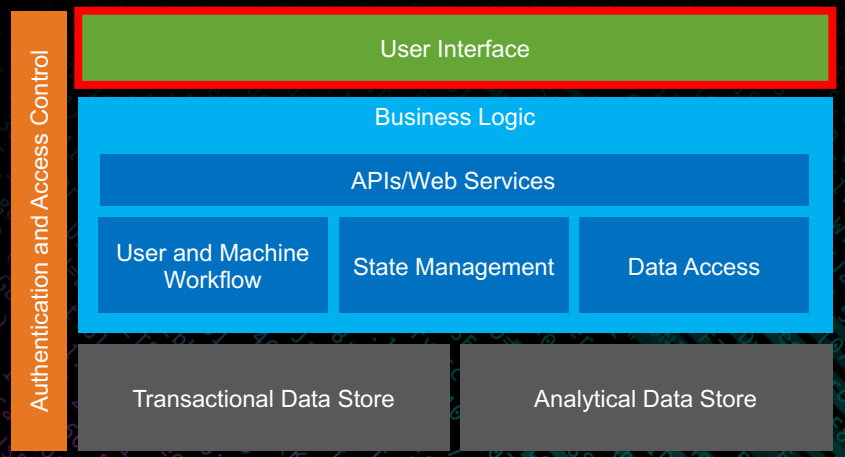
Anatomy of an Enterprise Web Application



User Interface



1. Functionality

- Forms and modal dialogs to capture RMF user input, e.g. assessment findings, audit findings, system boundaries, organization-defined parameters, etc.
- Custom input elements to navigate hierarchical data structures, e.g. org structures
- Control dashboards with dynamic visualizations that vary based on the control selected

2. Implementation on Splunk

- Highly customized JavaScript and SimpleXML
  - Pages have a companion JavaScript file
  - HTML templates and <html> SimpleXML tags to allow for modal dialogs and custom sections inside XML pages
  - Splunk Web Framework to create tables, charts, and input elements dynamically
  - jQuery, jsGrid and other JavaScript libraries to further improve the user experience

User Interface

SimpleXML and JavaScript based page

Scoring Overview and Categories

Edit | Export | ...

Organization and System

Qmulos / Windows

Score Type

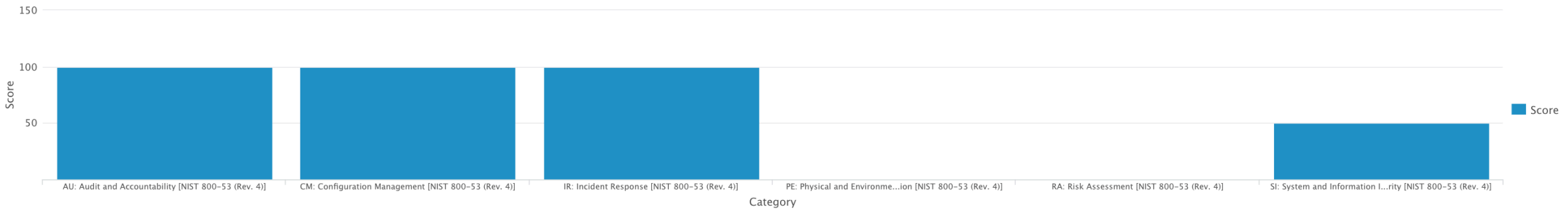
- (•) Assessment
- ( ) Audit

Hide Filters

FEDRAMP

DAILY	WEEKLY	10 DAYS	MONTHLY	60 DAYS
57.14%	100.00%	100.00%	72.73%	100.00%
90 DAYS	**ANNUALLY**	**2 YEARS**	**3 YEARS**	**5 YEARS**
75.00%	67.50%	100.00%	50.00%	0.00%

DAILY



DAILY

Control Name	Score
AU-02	100.00
CM-08(03)	100.00
IR-06	100.00

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User Interface

SimpleXML and JavaScript based page

SimpleXML

```
<fieldset autoRun="true" submitButton="false">
  <html>
    <div id="orgselect"></div>
  </html>
  <input id="typet" type="radio" token="type">
    …
</fieldset>
```

```
<row>
  <panel>
    <html>
      <div id="categories"></div>
    </html>
  </panel>
</row>
```

```
<row id="category" depends="$displaycat$">
  <panel>
    <table id="scoretable">
      <title>$category$</title>…
    </table>
  </panel>
</row>
```

JavaScript

Using JavaScript and HTML Template on page load

```
$("#orgselect").html(OrgSystemTemplate);
```

Using jQuery, SingleView and PostProcessManager

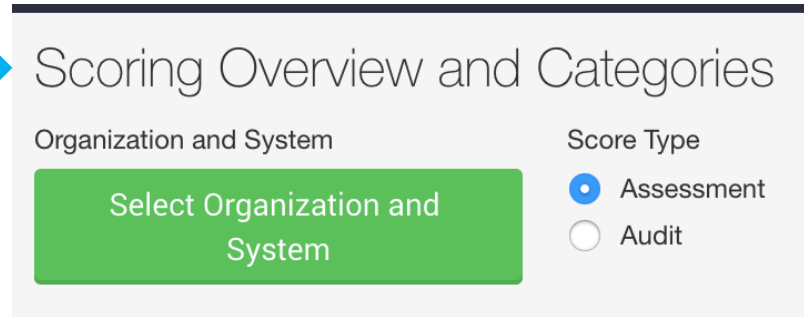
```
new PostProcessManager({…});
new SingleView({…});
```

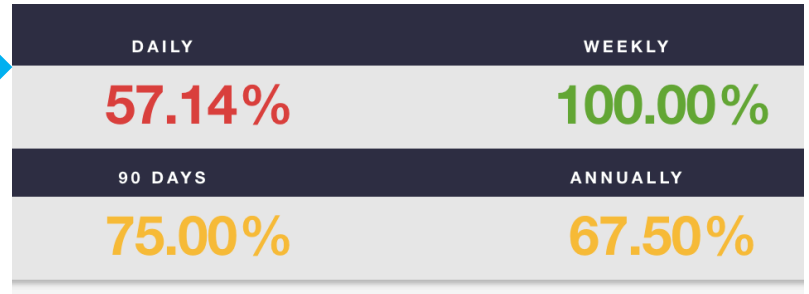
http://docs.splunk.com/Documentation/WebFramework

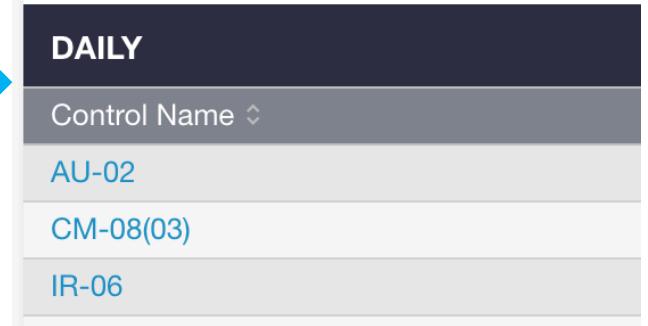
Setting tokens in the JavaScript

```
var tokens =
mvc.Components.get("default");
tokens.set("category", score_cat);
```

http://dev.splunk.com/view/webframework-developapps/SP-CAAAEW3







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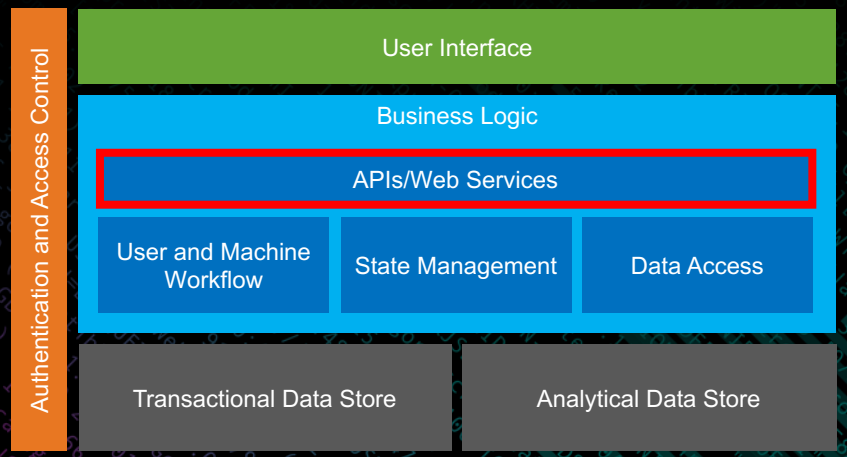
APIs/Web Services



1. Functionality

- User interface access to business logic and data through APIs/web services, e.g.
  - Configure applicable controls and parameters for a system
  - Access system's compliance data
  - Upload/download compliance evidence
- Integration with 3rd party GRC tools
  - Share compliance data with other GRC tools in a customer's environment

2. Implementation on Splunk

- Implemented in Python with 2 approaches
  a. Custom cherrypy controllers
     - Part of the older Module System's MVC architecture
  b. Custom REST endpoints
     - Extending Splunk's REST API with custom endpoints
     - More "official", preferred way to do it

APIs/Web Services

Two options for implementing custom web services in Splunk

Custom cherrypy controller

web.conf

[endpoint:custom_controller]
- Expose the controller through Splunk Web at a particular URL path

custom_controller.py

- Implementation of the web service
- Definition of which python functions are exposed through which HTTP methods
- Inherits from controller.BaseController

- Good (but old) example of custom controllers on Splunk wiki: https://wiki.splunk.com/Community:40GUIDevelopment

Custom REST endpoint

restmap.conf

[script:custom_endpoint]
- Define the endpoint
- URL path to match
- Handler (python code) that implements the endpoint

web.conf

[expose:custom_endpoint]
- Expose the endpoint through Splunk Web at a particular URL path
- Supported HTTP methods

custom_endpoint.py

- Implementation of the web service
- inherits from splunk.rest.BaseRestHandler

- Excellent blog series from Hurricane Labs: https://www.hurricanelabs.com/splunk-tutorials/splunk-custom-endpoints-part-1-the-basics

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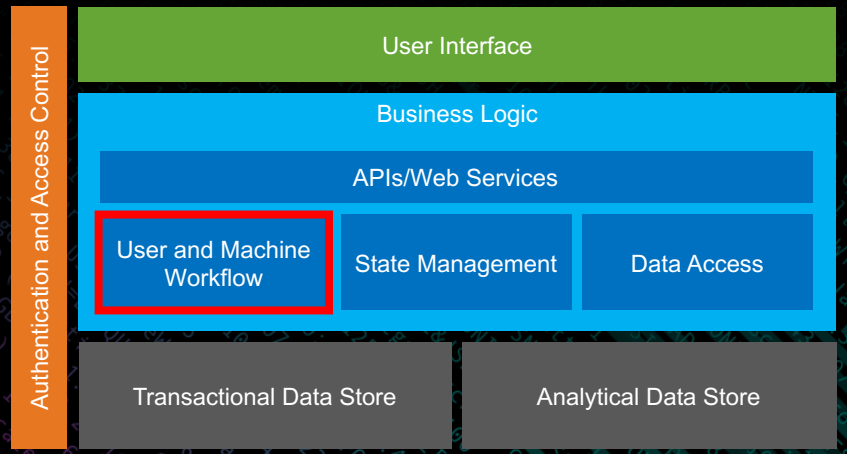
User and Machine Workflow



1. Functionality

- Interlinked screens to guide users through the 6 steps of the RMF process
- Dynamic custom drilldowns to guide users through different sub-flows within a given step
  - Reviewing a system-specific control vs. an inherited control from the Security Controls Traceability Matrix (SCTM) dashboard
- Custom alert actions to automate compliance assessments, notify users and invoke remediating actions

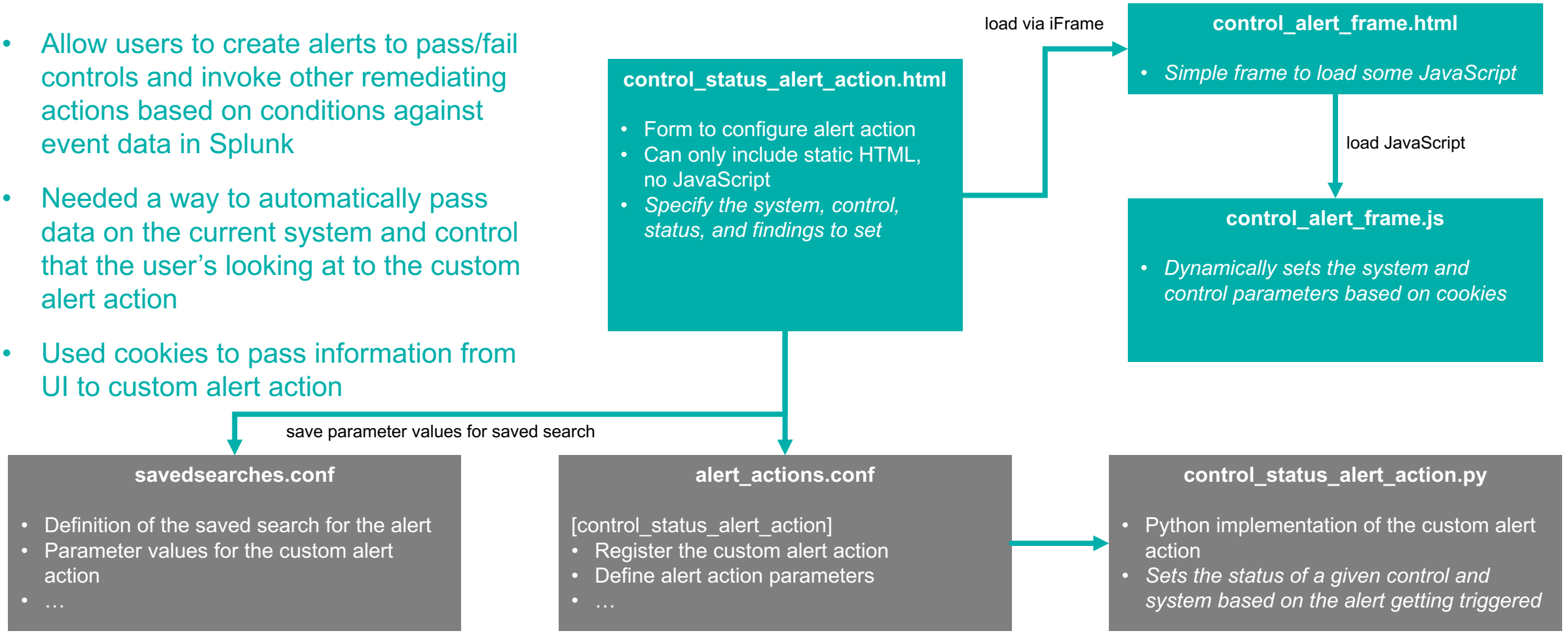
2. Implementation on Splunk

- Custom drilldowns to link dashboards together in a workflow (implemented in SimpleXML and JavaScript)
  - http://docs.splunk.com/Documentation/Splunk/latest/Viz/DrilldownIntro
- Tokens to pass state information across dashboards
- Custom alert action scripts (implemented in Python) that integrate with the standard Splunk alerting workflow
  - http://docs.splunk.com/Documentation/Splunk/latest/AdvancedDev/CustomAlertScript

User and Machine Workflow

An example on how to integrate user and machine workflows

- Allow users to create alerts to pass/fail controls and invoke other remediating actions based on conditions against event data in Splunk
- Needed a way to automatically pass data on the current system and control that the user's looking at to the custom alert action
- Used cookies to pass information from UI to custom alert action



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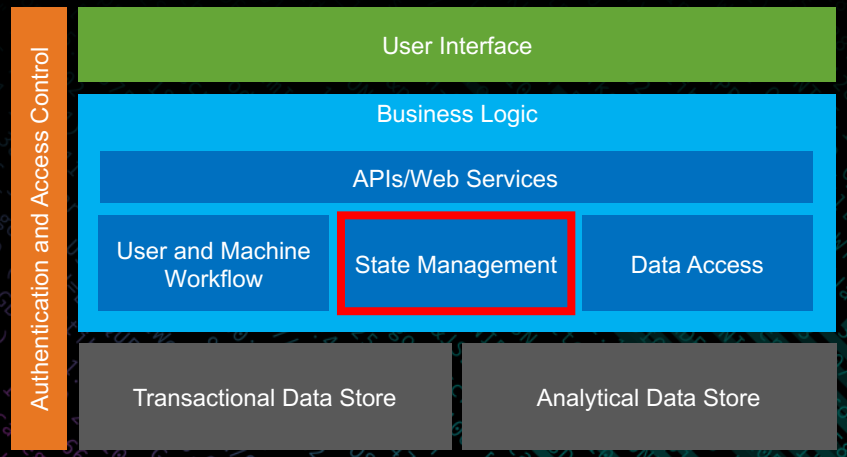
State Management



1. Functionality

- Manage and store the state of key entities as they transition through the workflows:
  - Organizations
  - Systems
  - Controls
- Maintain the state of user interactions as they navigate across different dashboards and pages, e.g. currently selected orgs, systems, controls

2. Implementation on Splunk

- All dashboards, pages, web services are stateless, i.e. we don't maintain any session state
- Custom drilldowns and tokens are used to pass state data across different dashboards and pages
- All state data is stored in cookies and our transactional data store, i.e. KV store
  - Cookies to keep track of currently selected orgs and systems
  - System's state within the RMF process stored across multiple tables in transactional data store

State Management

Store state data in cookies and populate tokens with cookie values

Use js-cookies to manage cookies in JavaScript:
https://github.com/js-cookie/js-cookie

control_dashboard.js

```
require(["js-cookie", "splunkjs/mvc"],
  function(Cookie, mvc) {
    $(document).ready(function () {
        var setSystemCookie = function (value) {
            if (value && (value !== "*")) {
                Cookie.set("Q-Compliance_system", value);
            } else {
                Cookie.remove("Q-Compliance_system");
            }
        };

        var getSystemCookie = function () {
            var value = Cookie.get("Q-Compliance_system");
            if (!value) {
                value = undefined;
            }
            return value;
        };

        var tokens = mvc.Components.get("default");
        tokens.set("system", getSystemCookie());
    });
});
```

control_dashboard.xml

```
<dashboard script="control_dashboard.js">
    <row>
        <panel>
            <chart>
                <search>
                    <query>
                        | pivot Q_Account_Management
Account_Management dc(user) AS "Number of Accounts"
SPLITROW action AS action FILTER system is $system$ SORT
100 action ROWSUMMARY 0 COLSUMMARY 0 SHOWOTHER 1
                    </query>
                </search>
            </chart>
        </panel>
    </row>
</dashboard>
```

Filter the query in the dashboard with a system value that the user previously selected on another page

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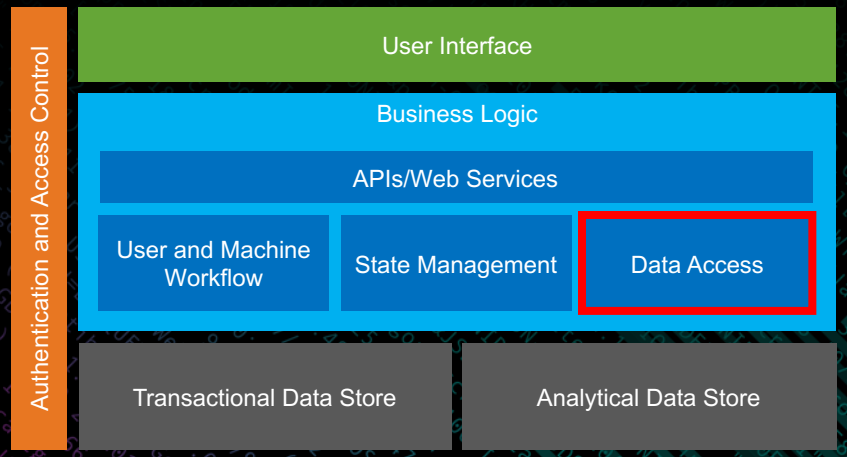
Data Access



1. Functionality

- Access to various technical control evidence in the form of raw event data and accelerated data models
- Create/Read/Update/Delete access to RMF objects (e.g. organizations, systems, controls) through the KV stores

2. Implementation on Splunk

- Three different way of accessing data:
  - Through search queries directly embedded in the SimpleXML
  - Through JavaScript AJAX calls that use the Splunk REST endpoints for CRUD KV store operations or the Splunk search endpoint to retrieve more complex data
  - Through the Python SDK inside backend web services and custom alert actions

Data Access

The three different ways of accessing data

Data Access Type	Example	Pros	Cons
SimpleXML Query	<query> |inputlookup q-compliance_system_info</query>	• Easy to create • Easy to update in the XML	• Limited to mostly reads • Editing the KV store is difficult through search queries (outputlookup)
JavaScript using Splunk Data Endpoints	Splunk.util.make_url("/splunkd/__raw/servicesNS/nobody/Q-Compliance/storage/collections/data/kv_system_info); http://dev.splunk.com/view/webframework-developapps/SP-CAAAEZG	• Can do direct CRUD operations	• Requires a JavaScript file which moves the edits away from the XML
Python SDK	client.kvstore['kv_system_info’]; http://dev.splunk.com/python	• Data Layer separation • Allows for API with other apps	• Requires a custom endpoint

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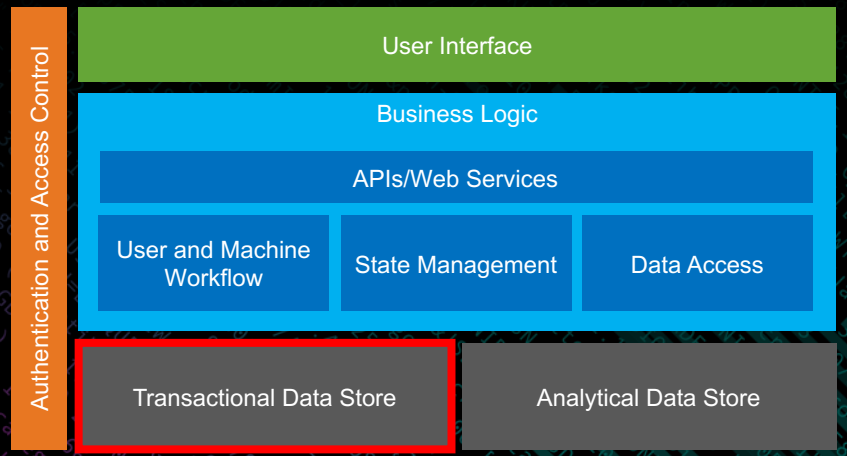
Transactional Data Store



1. Functionality

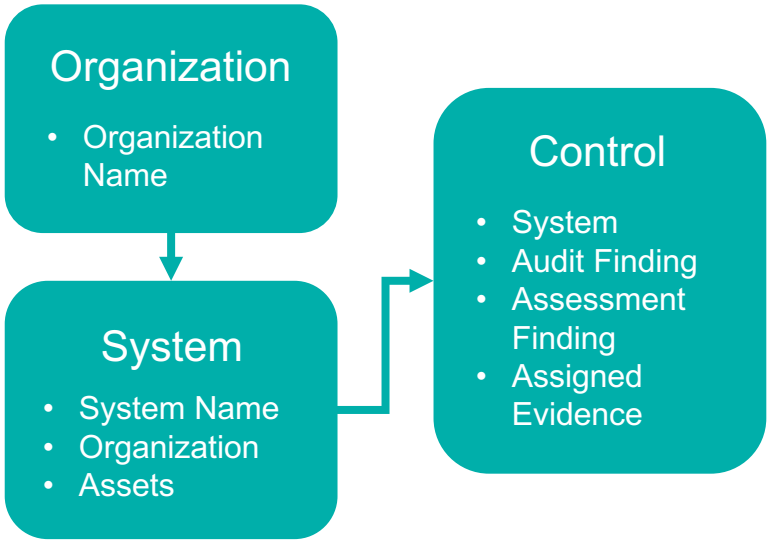
- Full blown database to store key RMF entities (e.g. organizations, systems, controls)
- Store the state of key entities and user interactions as they progress through different workflows
- Allow application customers to have a unique environment that represents their own security posture, important findings, and dependencies

2. Implementation on Splunk

- KV store implemented as a traditional entity-relationship structure, not just for lookups
- Create default datasets and have procedures for data migrations, application upgrades, and backwards compatibility

Transactional Data Store

Using KV store as a truly transactional data store



Maintenance Scenarios (in Splunk):

- Populating the Organization and System entities
  - Create the entities in collections.conf and transforms.conf
  - Create a User Interface which writes to the KV store using the Splunk endpoints or outputlookup search queries
  - Create a default dataset by making CSV lookups of organizations and systems and use saved searches to write to the KV store (|inputlookup ~.csv | outputlookup …)
- Updating the Control entity to include Next Assessment Date
  - Update the entity structure by editing the collections.conf and the transforms.conf
  - Update the User Interface to write the Next Assessment Date when editing a new Control
  - Create a data migration saved search that adds a default Next Assessment Date for all existing records (|inputlookup …| eval Next_Assessment_Date=..| outputlookup…)
- Add functionality to remove Controls for Systems that are deleted
  - Update the User Interface to remove Control entities when removing Systems
  - Create a purge script that removes Controls for System entities that don't exist (|inputlookup … | join … | where … | outputlookup …)

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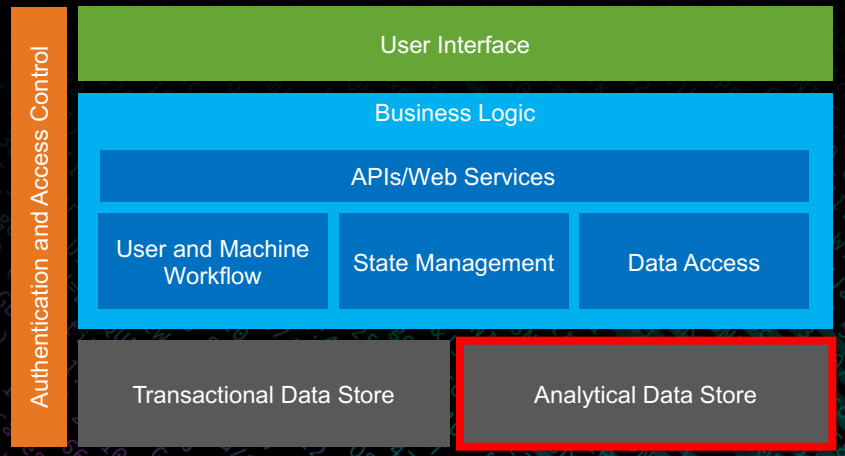
Analytical Data Store



1. Functionality

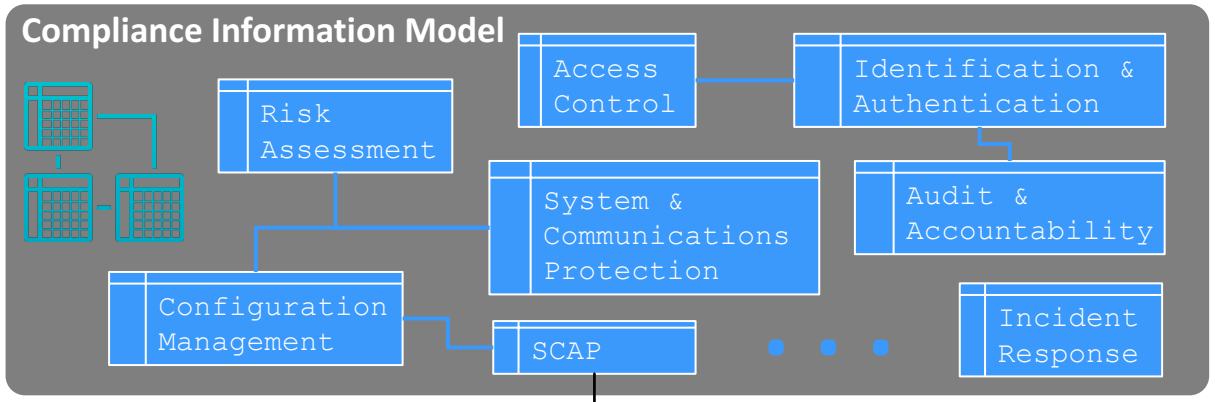
- Stores raw events, object-level details
- Drives the analytics and visualizations that assist with assessing control compliance
- Data models specific to security domains covered by NIST 800-53 controls – *"Qmulos Compliance Information Model (Q-CIM)"*

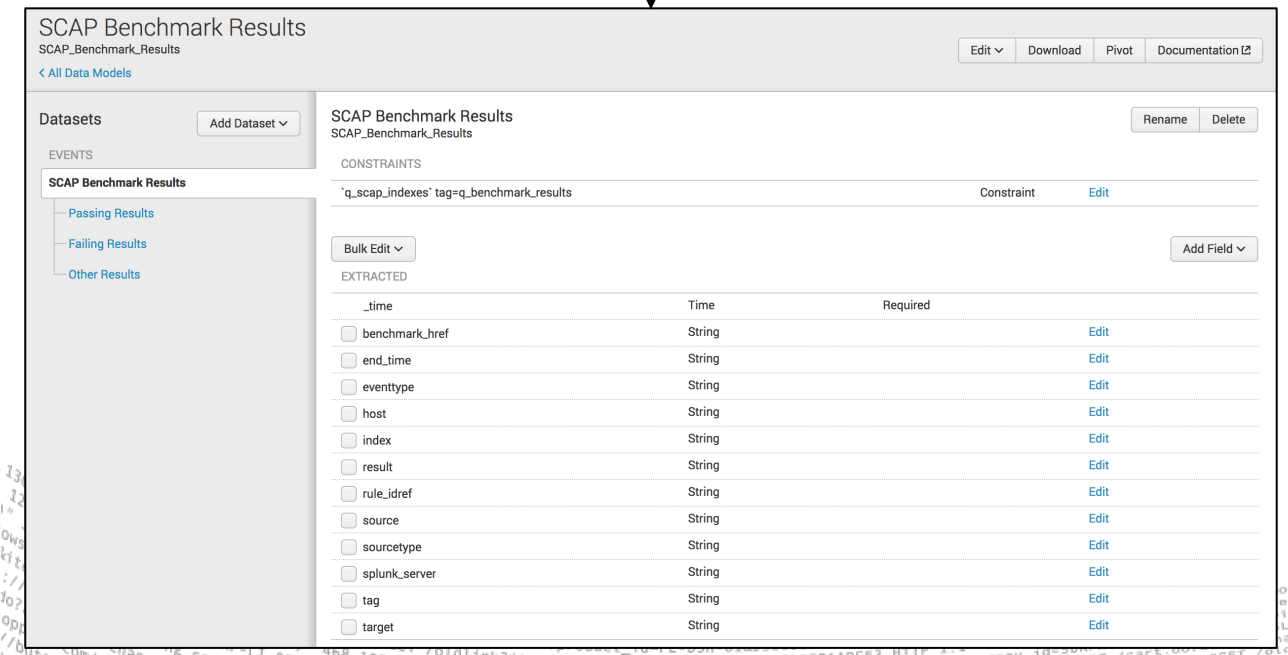
2. Implementation on Splunk

- Event data stored in indexes
- Accelerated data models
  - http://docs.splunk.com/Documentation/Splunk/latest/Knowledge/Aboutdatamodels
- Extension of Splunk's Common Information Model where relevant
  - http://docs.splunk.com/Documentation/CIM/4.11.0/User/Overview

Analytical Data Store

Things to consider when working with Splunk datamodels





- Take a “waterfall approach” and do some rigorous analysis and design upfront
- Very disruptive to change your datamodels when customers and partners already have queries built using earlier versions
- Use Splunk CIM (or extend from it) as much as possible – makes data onboarding easier

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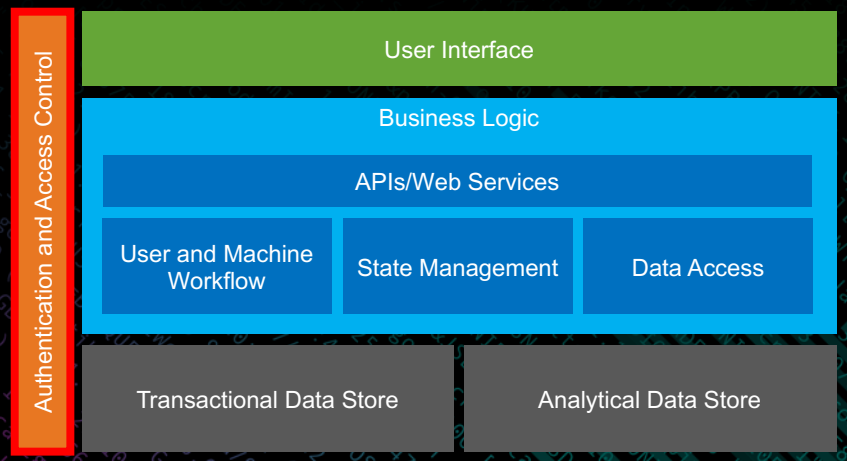
Authentication and Access Control



1. Functionality

- Capability access control: Restrict access to “controlled capabilities” (such as creating an assessment or deleting a system) by roles
- Data access control: Control who can see which system’s compliance and evidence based on what organizations they belong to

2. Implementation on Splunk

- Create roles that represent capabilities inside the application using authorize.conf (e.g. auditor, assessor)
- Add index role permissions to secure event data (e.g. an auditor might only see a summary index)
- Add collections permissions to default.meta to restrict read/write access to KV stores (e.g. only a system manager should be able to modify a system entity)
- Add views permissions to default.meta to restrict the pages that different roles can access (e.g. some pages should require a user to be admin)
- Use JavaScript to hide buttons/tables/other elements based on role to show a clean UI of what a user can do

Authentication and Access Control

Securing your Splunk web application

User Interface

- Access to Pages
  - Set page permissions for roles using default.meta
- Access to UI elements within a page
  - Get user roles through REST call
  - Hide the elements using custom JavaScript and CSS

Business Logic

- Restrict the data displayed in the User Interface to “subset” the user should see
  - Create custom REST endpoints to create the proper subsets of data
  - Add business logic to alert an user if they don’t have access and to narrow the input options (if they try to access data through a URL parameter)

Data Stores

- Restrict access to KV Store
  - Set proper write permissions
  - Create a default role that has the basic read permissions
- Restrict access to Index data
  - Add index permissions to particular roles
  - Separate data into organization based indexes

Authentication and Access Control

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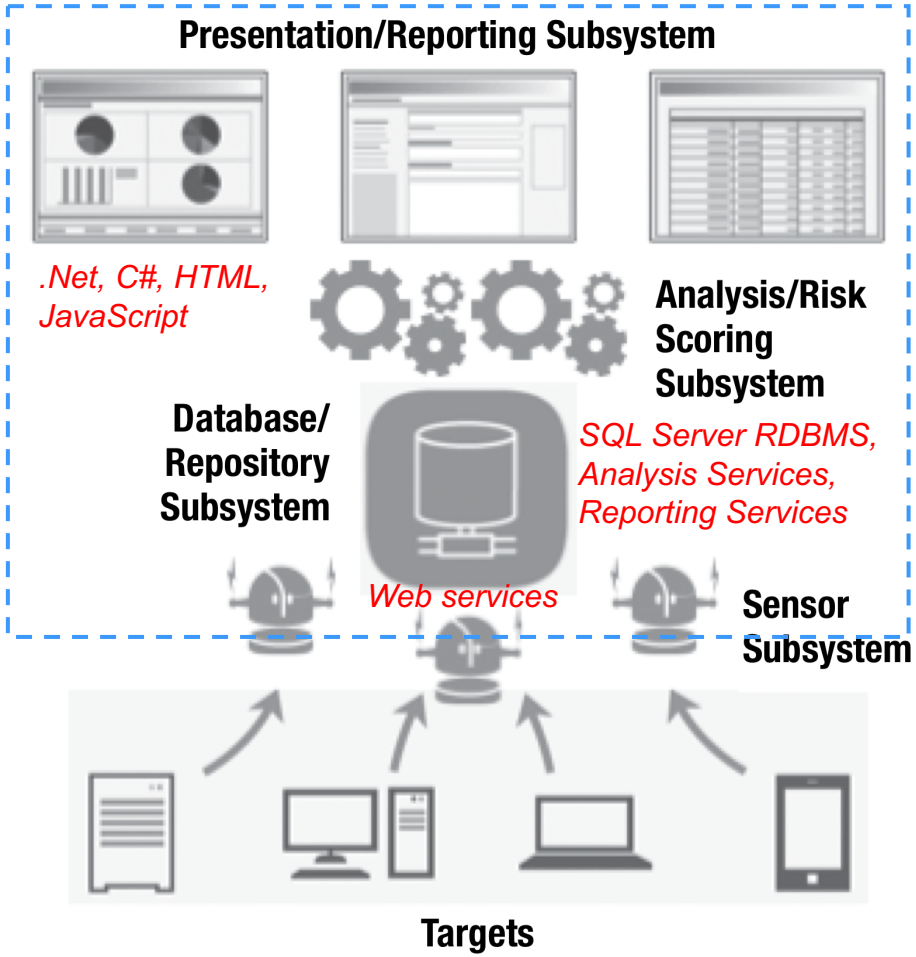
Comparison with Building from Scratch/Open Source

Previous experience building an enterprise continuous monitoring system covering two million assets



- Initial implementation - .Net stack with SQL Server backend
- Eventually migrated to Java and Hadoop to scale out
- Charts, graphs, tables were all custom implemented
- Lots of time spent on data integration code
  - Limited number of data sources that were integrated
- Scalability was a challenge

Took more time and resources but had less functionality

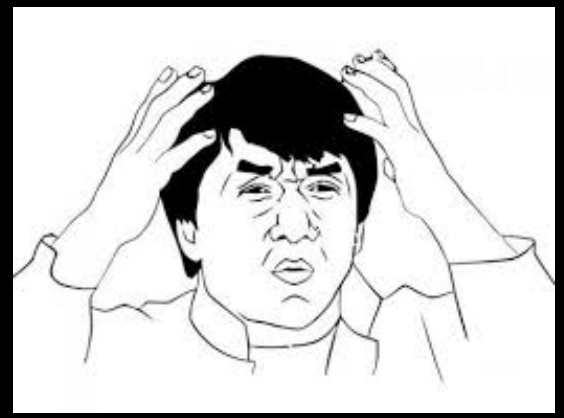
Case study in ISACA Journal: https://www.isaca.org/Journal/archives/2015/Volume-1/Pages/Implementing-an-Information-Security-Continuous-Monitoring-Solution.aspx

Key Takeaways

Splunk is a powerful platform for building modern enterprise web applications

- Tremendous productivity enhancer vs. building from scratch or using open source platforms but business logic and queries embedded in SimpleXML will only get you so far
- Do some upfront design and have a target architecture in mind, this will reduce refactoring pain later
- Apply common web architectures/design patterns, e.g. MVC (Model-View-Controller), CQRS (Command Query Responsibility Segregation), micro-services, etc.

Developing on top of Splunk

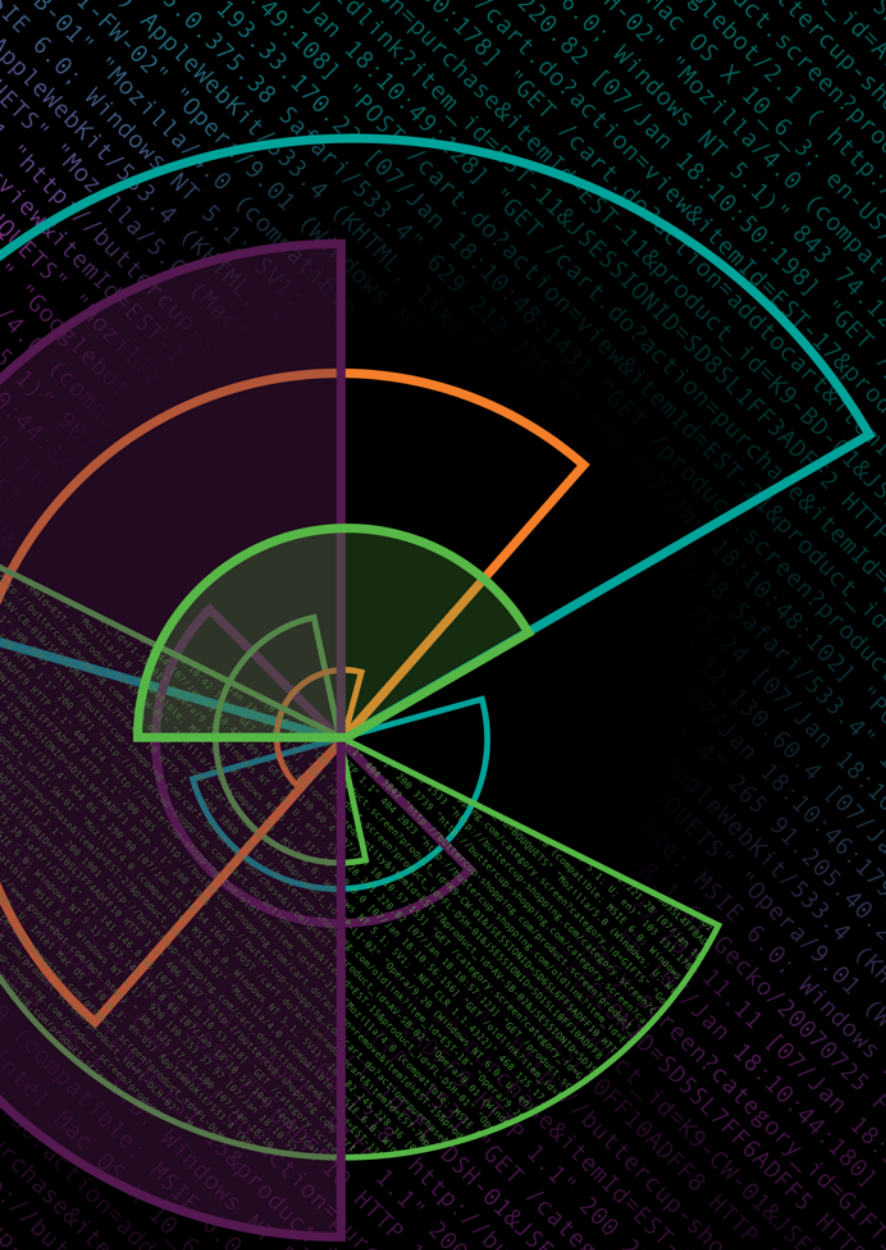


Developing from scratch/open source

Links to Useful Resources

Subsystem	Useful Resources for Implementation
User Interface	• Splunk Web Framework: http://docs.splunk.com/Documentation/WebFramework • Setting tokens in JavaScript: http://dev.splunk.com/view/webframework-developapps/SP-CAAAEW3
APIs/Web Services	• Custom controllers (the old way): https://wiki.splunk.com/Community:40GUIDevelopment • Custom REST endpoints (the new way): https://www.hurricanelabs.com/splunk-tutorials/splunk-custom-endpoints-part-1-the-basics
User and Machine Workflow	• Custom drilldowns: http://docs.splunk.com/Documentation/Splunk/latest/Viz/DrilldownIntro • Custom alert actions: http://docs.splunk.com/Documentation/Splunk/latest/AdvancedDev/CustomAlertScript
State Management	• KV Stores: http://dev.splunk.com/view/webframework-developapps/SP-CAAAEZK • JavaScript API for cookies: https://github.com/js-cookie/js-cookie
Data Access	• Accessing Splunk KV endpoints in JavaScript: http://dev.splunk.com/view/webframework-developapps/SP-CAAAEZG • Splunk Python SDK: http://dev.splunk.com/python
Transactional Data Store	• KV Stores: http://dev.splunk.com/view/webframework-developapps/SP-CAAAEZK
Analytical Data Store	• Splunk Datamodels: http://docs.splunk.com/Documentation/Splunk/latest/Knowledge/Aboutdatamodels • Common Information Model: http://docs.splunk.com/Documentation/CIM/4.11.0/User/Overview
Authentication and Access Control	• Creating roles in Splunk: https://docs.splunk.com/Documentation/Splunk/7.1.2/Security/Addandeditroleswithauthorizeconf • Set permissions for objects in Splunk: http://dev.splunk.com/view/webframework-developapps/SP-CAAAE88

splunk> .conf18



Q&A

www.qmulos.com

Thank You

Don't forget to rate this session in the .conf18 mobile app