Exploring Browser Frameworks: A Comparative Analysis and Deployment Demo

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The ACORN Project is a DOE O413 project that will modernize the laboratory’s accelerator control system and replace end-of-life accelerator power supplies.

Approve Mission Need (CD-0) was approved August 28, 2020.

Approve Alternate Selection and Cost Range (CD-1) is projected to occur Q2 FY24 (March 2024).

Total Project Cost (TPC) range: 100 – 142M$

Project Completion (CD-4): 2028 – 2030
ACORN Mission Need Statement (CD-0)

ACORN received CD-0 approval August of 2020.

Mission Need Statement identified the following:

- ACNET (current control system) was developed four decades ago and uses hardware that is no longer available and software that is no longer maintainable.
- Many of the accelerator power supplies that drive the accelerator complex have exceeded their useful life, are not designed to modern safety standards, and cannot be controlled with the speed and precision needed for future accelerator operations.
The capability gaps for the control system were noted by the laboratory’s external Accelerator Advisory Committee (AAC) in its December 2018 report:

The existing lab-wide accelerator control system has aging and heterogeneous front-end hardware, multiple different frameworks and network protocols, 1980s era network services and a collection of generic functionalities. The top level is a mix of high-level software some of which is using obsolete frameworks. Recent targeted modernization has included rather specific, targeted initiatives. Major issues include: lots of old hardware; lots of old software, and an aging and declining in strength work force (no software development related hires since 2001 for instance).
ACNET control system history of upgrades

• The accelerator control system has been essential to scientific discoveries at Fermilab for decades.
• System upgrades have been occurring throughout its history without causing major beam downtimes:
  • Upgrading from PDP-11 to VAX
  • Moving from VAX to Linux servers
  • Transitioning from a proprietary database to a commercial database
  • Moving from a commercial database to an open-source database
  • Introduction of Java Controls for central services, applications, and data acquisition.
  • Development and expansion of the Data Pool Manager central service
  • Countless fieldbus hardware upgrades (CAMAC module development, IRM/HRM, BSSB/MFTU)
• The ACORN project represents the first major overhaul of the accelerator control system in the past 40 years. The scale of this project requires it to be a DOE O413 project.
### Existing Application Development Tools and Processes

- Complex user interfaces that require extensive training or are difficult to navigate, resulting in user frustration and errors.
- Inconsistent design across different applications or within the same application, leading to confusion and reduced efficiency.
- Poor readability due to small or low-contrast fonts, color schemes that strain the eyes, or lack of visual hierarchy.
- Overwhelming or cluttered interfaces that present too much information at once, making it difficult for users to find what they need.
- Insufficient feedback, such as a lack of confirmation messages or visual cues, leaving users uncertain whether their actions were successful or not.
ACORN Requirements Structure

• Requirements derived from use cases
  Used missing use cases and requirements to highlight requirements that needed more work
  Derived new requirements to fill gaps in requirements

• Created levels which correspond to the use case levels
  Going from top level to low levels answers “How?”
  Going from low levels to top level answers “Why?”

• The use case number used to derive the requirement is included in the requirement’s record along with a link to the specific use case.
  Can trace the requirement all the way back to the recording of the interview if desired.
# ACORN System Requirements

<table>
<thead>
<tr>
<th>Project ID</th>
<th>Name</th>
<th>Description</th>
<th>Status</th>
<th>Use Case Number</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACORN-ACORN_SYS-17</td>
<td>Limit Data Acquisition Interfaces</td>
<td>The control system shall limit the number of interfaces for data acquisition.</td>
<td>Draft</td>
<td>UC-02300.001</td>
<td>Development</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-18</td>
<td>Expose Data Acquisition Interfaces</td>
<td>The control system shall expose standard interfaces for data acquisition.</td>
<td>Draft</td>
<td>UC-02300.002</td>
<td>Development</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-24</td>
<td>Personnel Safety Interlocks System Interface</td>
<td>The control system shall interface with the Personnel Safety Interlocks...</td>
<td>Draft</td>
<td>UC-02250.001</td>
<td>Interfaces</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-25</td>
<td>Building Automation Systems Interface</td>
<td>The control system shall interface to the Metasys facilities management...</td>
<td>Draft</td>
<td>UC-01960.001</td>
<td>Interfaces</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-26</td>
<td>Beam Instrumentation Data Acquisition</td>
<td>The control system shall support data acquisition at rates relevant to...</td>
<td>Draft</td>
<td>UC-02130.001</td>
<td>Interfaces</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-27</td>
<td>Machine Protection</td>
<td>The control system shall allow external systems to inhibit beam.</td>
<td>Draft</td>
<td>UC-02380.001</td>
<td>Interfaces</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-55</td>
<td>Non-Expert Displays</td>
<td>The control system shall provide the tools for a non-expert user to dev...</td>
<td>Draft</td>
<td>UC-01600.001</td>
<td>User Interface</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-56</td>
<td>Accelerator Dashboard</td>
<td>The operations interface shall provide an initial screen providing a dis...</td>
<td>Draft</td>
<td>UC-01720.001</td>
<td>User Interface</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-57</td>
<td>Create User Displays</td>
<td>The control system shall let expert users create displays.</td>
<td>Draft</td>
<td>UC-01730.001</td>
<td>User Interface</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-58</td>
<td>Customize User Displays</td>
<td>The control system shall let expert users customize displays.</td>
<td>Draft</td>
<td>UC-01730.002</td>
<td>User Interface</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-59</td>
<td>Unlimited Screens and Applications</td>
<td>The control system's user interface shall not explicitly limit the amount...</td>
<td>Draft</td>
<td>UC-02350.006</td>
<td>User Interface</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-60</td>
<td>Control System Index</td>
<td>The control system shall provide an index of programs, scripts, and too...</td>
<td>Draft</td>
<td>UC-01740.001</td>
<td>User Interface</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-61</td>
<td>Browser Access</td>
<td>The control system shall be accessible via browsers.</td>
<td>Draft</td>
<td>UC-02110.001</td>
<td>User Interface</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-67</td>
<td>Beam Loss Visualization</td>
<td>The control system shall let operators visualize where beam loss is ha...</td>
<td>Draft</td>
<td>UC-01240.002</td>
<td>User Interface</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-70</td>
<td>Mobile Device Access</td>
<td>The control system shall support access from mobile devices.</td>
<td>Draft</td>
<td>UC-02110.002</td>
<td>User Interface</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-76</td>
<td>Vacuum Systems Interface</td>
<td>The control system shall provide an interface to vacuum systems.</td>
<td>Draft</td>
<td></td>
<td>Interfaces</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-77</td>
<td>Cooling Water Interface</td>
<td>The control system shall provide an interface to cooling watersystems.</td>
<td>Draft</td>
<td></td>
<td>Interfaces</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-78</td>
<td>Building Utility Interface</td>
<td>The control system shall provide an interface to building utility systems.</td>
<td>Draft</td>
<td></td>
<td>Interfaces</td>
</tr>
<tr>
<td>ACORN-ACORN_SYS-79</td>
<td>Tunnel Utility Interface</td>
<td>The control system shall provide an interface to tunnel utility systems.</td>
<td>Draft</td>
<td></td>
<td>Interfaces</td>
</tr>
</tbody>
</table>
Reasons we are pursuing to browser applications

- Cross-platform
  - This is not free, but it’s work in every ecosystem. We believe that developing for the browser, we limit the context switching for developers.
- Progressive Web Apps (PWAs), native-feel browser applications
- User Familiarity
- Support for mobile without cross-compilation
- Growing developer pool
- Usability tools and Human Factors compliance
Architecture Influence

Alternative 3 - Centralized Control System

The influence of architecture on relationships between systems.

Services inside the EPICS are connected to services between each service as needed with a common protocol like gRPC, the exception is the proxy that saves the box with an explicit protocol.

The center boxes include interfaces to external systems.

DRAFT
Application Status

- Browser framework exploration (Dec 22-Feb23)
  - Developers chose interesting frameworks with the goal of sharing developer experience
- Prototyping critical applications
  - Parameter page – in progress
  - Plotting
  - Alarms

https://github.com/fermi-controls/parameter_page_app
New development and deployment pipelines

- We’ve adopted GitHub Actions for our continuous integration platform.
- After successful tests, the build is bundled into a container image and installed in our local image repository.
- We use Flux to monitor the image tags and build the newest version.
More Information

- Design Philosophy for Accelerator Control Rooms
  - [https://www.osti.gov/biblio/1960279](https://www.osti.gov/biblio/1960279)
- Style guide – coming soon
- Beau Harrison, ACORN User Applications L2 – beau@fnal.gov
- Rachael Hill, ACORN Human Factors Expert – rachael.hill@inl.gov
Thank you
Question prompts

• Why are there many solutions to applications?
• Can we agree that 20 to 30-year-old user applications aren’t supportable?
  – Is it possible to separate slowly-changing logic from the fast-changing user needs?
• Are the Fermi user application requirements common across facilities?
  – If not, is there a common set of requirements that make sense for EPICS users?
• If we agree on a common set of requirements, is there interest in sharing the development load through open-source development?
  – If so, what are the next steps?
• What can be shared across accelerators, others?
  – Human Factors research results?
  – Style guides?
  – Application frameworks?
  – Applications?