



Software Management for the NOvA Experiment

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NOvA AND NOvASOFT

- * NOvA is a long-baseline neutrino oscillation experiment.
- * It consists of two detectors: Far Detector (FD) near International Falls, Minnesota and Near Detector (ND) at FNAL, Illinois
- * The FD is 14 kt and the ND, 0.3 kt
- * NOvA uses the NuMI beam from FNAL, mainly ν_μ in composition
- * NOvA is located 14 mrad off-axis from the NuMI beam to maximize oscillation probability
- * The ND will be used to measure the beam spectrum and composition before oscillation
- * It will enable the study of $\nu_\mu \rightarrow \nu_e$ oscillation (ν_e appearance) and also $\nu_\mu \rightarrow \nu_\mu$ oscillation (ν_μ disappearance)
- * The detectors are composed of PVC modules that consist of tubular cells filled with liquid scintillator.
- * Alternate modules are orthogonal in orientation to enable 3-D reconstruction.
- * A loop of optical fiber runs through every cell, each read out by an Avalanche Photo-Diode (APD)

The international nature of the experiment poses a challenge for providing computing access to all collaborators. The NOvA Offline Analysis Software (NOvASoft) is written in C++ and built on Fermilab Computing Division's ART framework that uses CERN's ROOT analysis software. NOvASoft makes use of more than 50 external software packages, is developed by more than 50 developers and is used by more than 200 scientists from 31

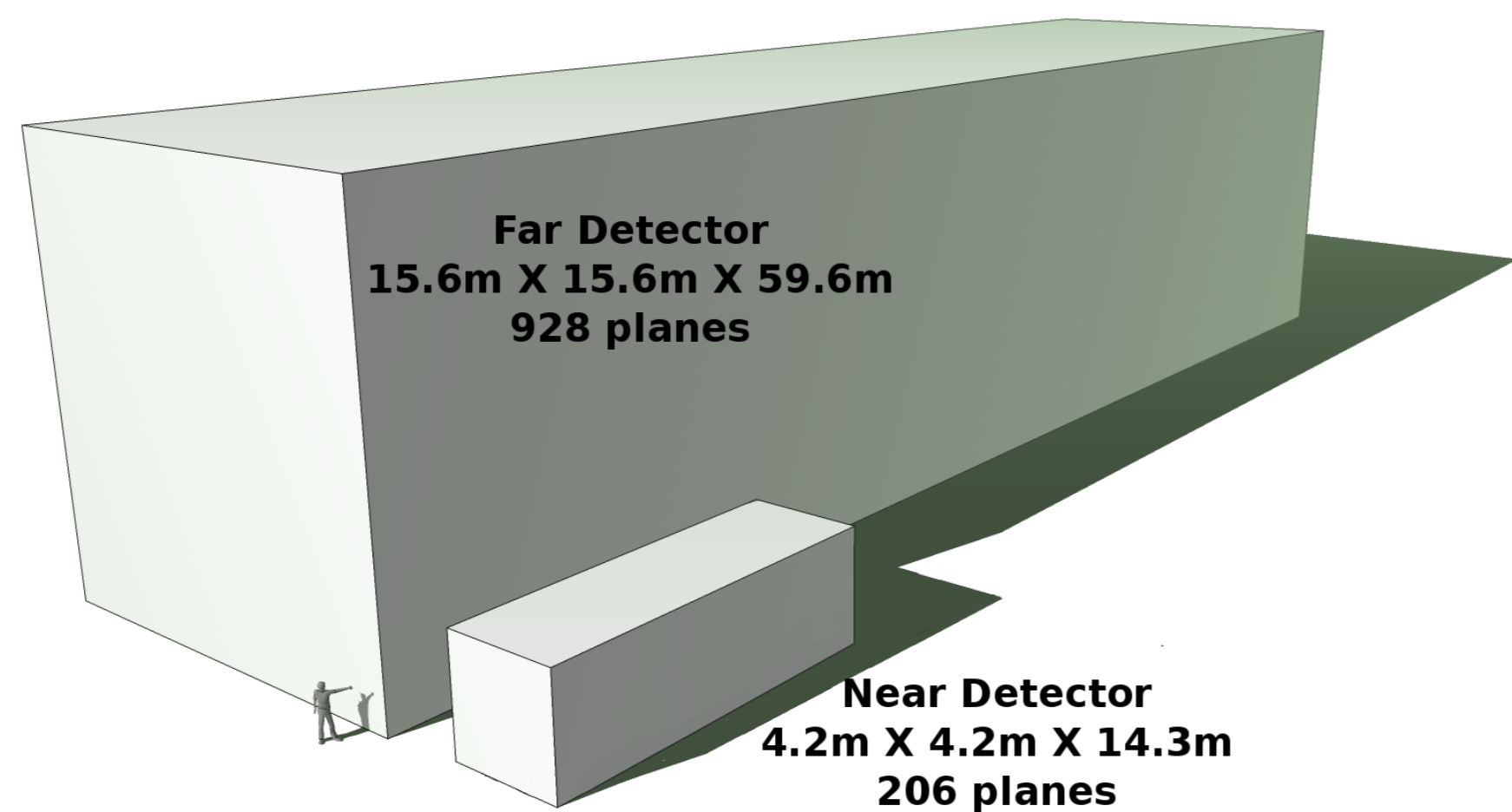


Figure: Top figure indicates the positions of the NOvA detectors while the bottom shows their relative sizes. NDOS was a prototype built to test detector systems.

SOFTWARE RELEASE TOOLS (SRT)

NOvASoft builds are handled by Fermilab's custom version of Software Release Tools (SRT), a UNIX based software management system for large, collaborative projects that is used by several experiments at Fermilab. The system provides software version control with SVN configured in a client-server mode and is based on the code originally developed by the BaBar collaboration.

One of the most powerful concept in SRT build system is a *Test Release*, where a user can checkout only a subset of packages from the repository, that they are interested in working on. SRT picks up the libraries for the packages not in the test release from a base release common to all users. Test releases are flexible and provide a convenient and quick way for users to work on multiple, unrelated projects in parallel. No time or space is wasted on locally building packages that have little to do with the user's current work.

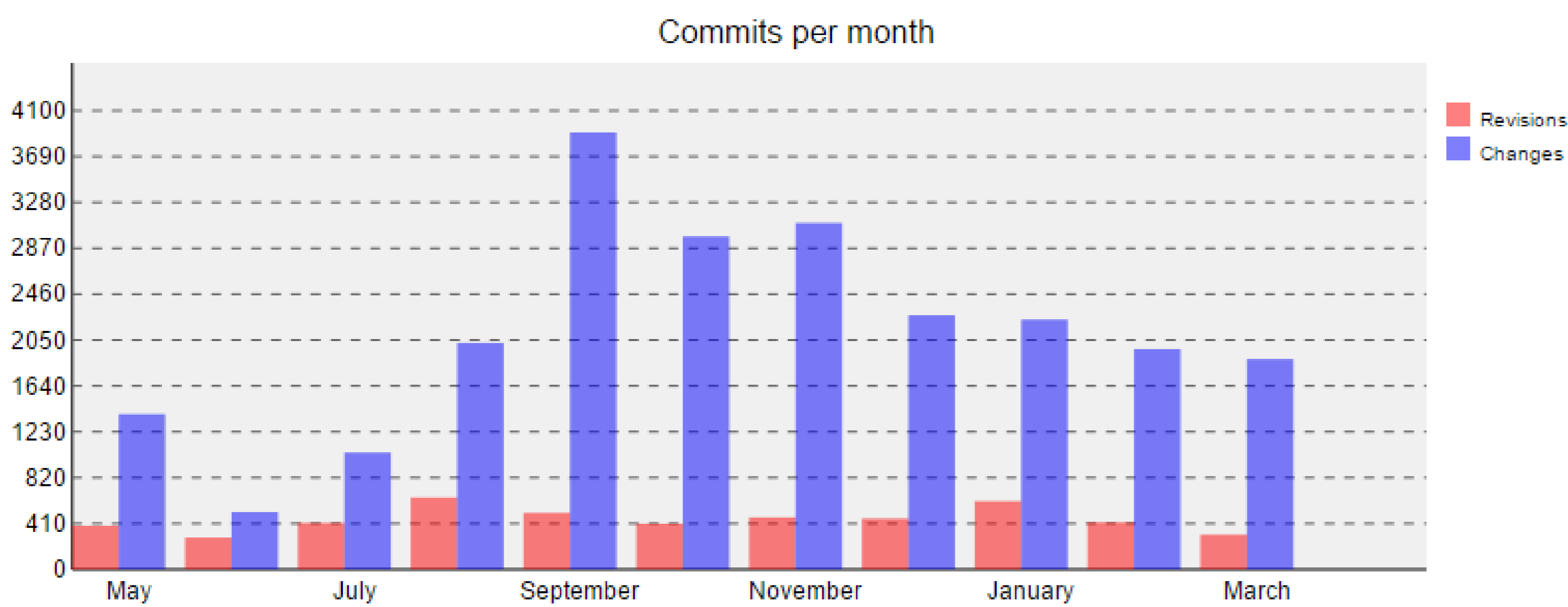


Figure: Figure shows the frequency of svn commits to NOvASoft over the course of a year. NOvASoft developers average approximately 2000 svn commit changes per month and around 400 revision changes.

CMAKE

CMake provides an alternative build system to the SRT system currently used by NOvASoft. Test releases while a convenient resources are known to produce inconsistent local build related problems that are difficult to debug. CMake does away with test releases and requires each user to have a local copy of the entire repository.

The CMake build system has been adapted by Fermilab's Computing Division to interface with the UPS package management system (see next panel). It is completely implemented for NOvASoft and is in use alongside of SRT.

Since CMake is the industry standard, it has the additional advantage of ample documentation and help on technical forums on the Web.

REFERENCES

- * UPS/UPD: <http://www.fnal.gov/docs/products/ups/ReferenceManual/>
- * Jenkins: <http://jenkins-ci.org/>

UPS AND UPD

The software for experiments rely on external tools. These packages and tools are referred to as external products, or simply products. For Fermilab-based experiments, access to external products is provided by a Fermilab-developed product-management package called Unix Product Support. UPS supports multiple versions of a product and builds per version. A product is built multiple times for use with different versions of an operating system, C++ compiler or optimisations. UPS provides a way to select a particular build. The full identifier of a UPS product includes:

- * product name
- * version
- * flavour
- * full set of qualifiers

UPD (UNIX Product Distribution) is a companion product to UPS, and provides the functionality for uploading/downloading products between local systems and product distribution servers. NOvASoft uses UPS for some internal products as well because of the ease in which they can be distributed via UPD, for example:

- * upd install product version

This enables us to easily distribute any software to any (supported) system, to run our code on and connect our collaborators.

CERNVM FILE SYSTEM (CVMFS)

CernVM File System (CVMFS) is a network file system based on HTTP and optimized to deliver experiment software in a fast, scalable, and reliable way. Files and file metadata are aggressively cached and downloaded on demand. CVMFS client provides a virtual file system that loads data only on access. All releases of NOvASoft are hosted as a CVMFS repository on a web server. Data transfer via HTTP removes any requirement on installing or building NOvASoft locally at non-Fermilab locations.

- * Filesystem with a single source of data (repository Stratum 0) maintained by a dedicated release manager machine
- * CVMFS server tool kit publishes the current state of the repository on the release manager machine
- * Repositories are replicated to a handful of web servers (Stratum 1) and data cached by standard web proxies such as Squid
 - * Squid is a caching proxy for the Web supporting HTTP, HTTPS, FTP etc
 - * Bandwidth requirement is reduced and response times improved by caching and reusing frequently-requested webpages

Currently NOvASoft maintained and published on an Open Science Grid (OSG) CVMFS server - nova.opensciencegrid.org - that hosts both stratum 0/1 servers. We have access via OSG to multiple clients and specific NOvA dedicated offsite clients that include Harvard University, Southern Methodist University, Institute of Physics of the Academy of Sciences (Prague, Czech Republic) and Ohio Supercomputing.

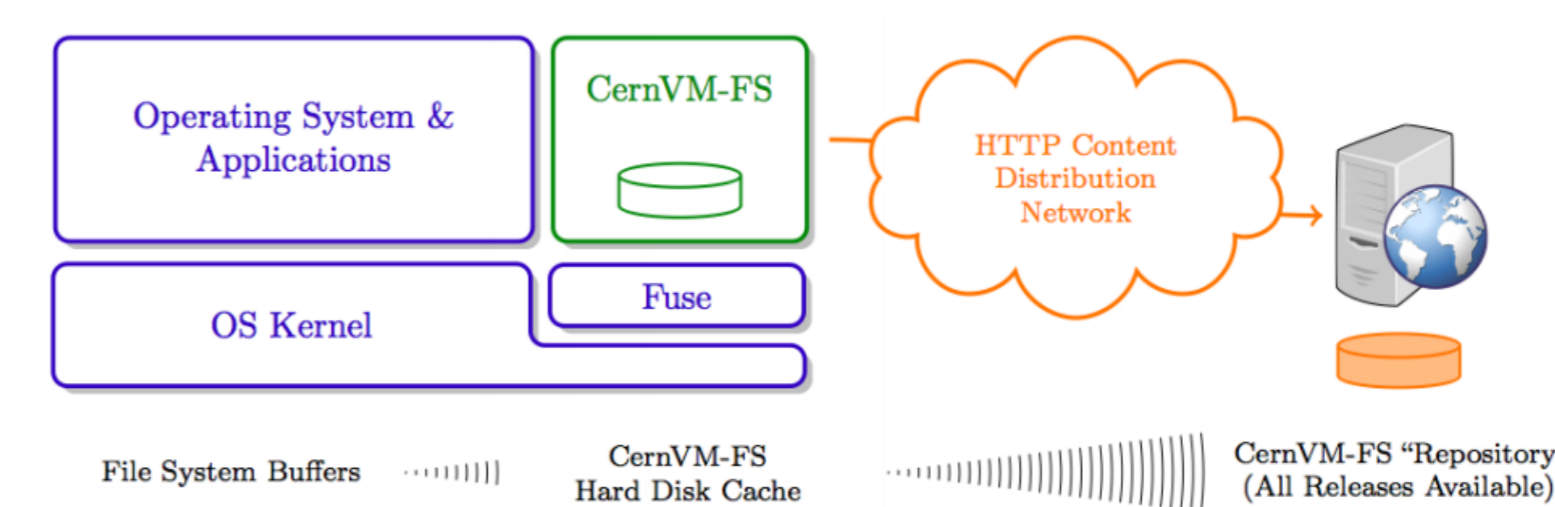


Figure: Pictorial representation of CVMFS and its relation to operating system and HTTP transfer to repository.

JENKINS

Jenkins is an award-winning application that monitors executions of repeated jobs, such as building a software project or jobs run by cron. Jenkins focuses on the following two jobs:

- * Building/testing software projects continuously
- * Monitoring executions of externally-run jobs

We build NOvASoft nightly for distribution to developers and use Jenkins as an early warning system for repository commits that will break the development code base and also for aiding with building different versions on different operating systems.

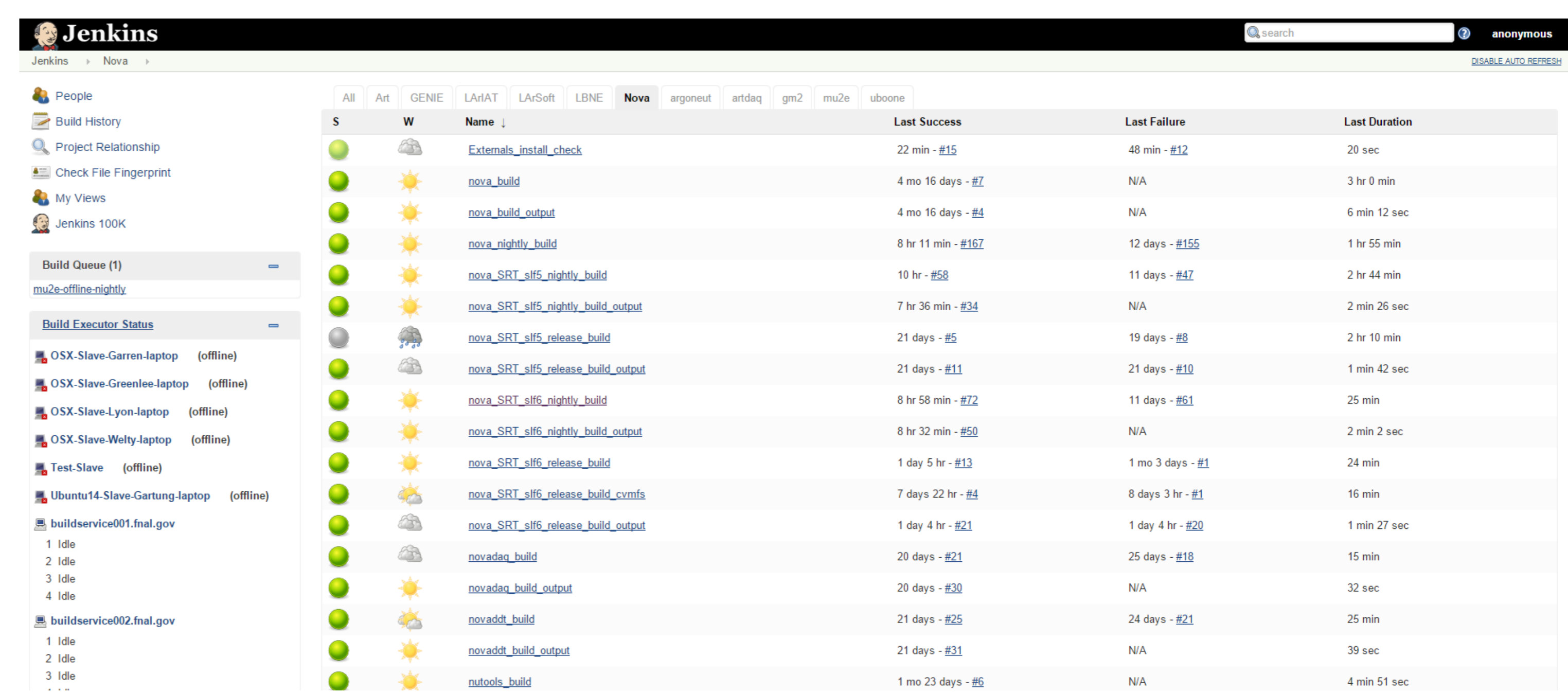


Figure: A snapshot of NOvASoft builds using the Jenkins application monitoring. It displays the current status of a particular build/flavour with duration, last success, last failure reported as well as a weather report showing the aggregated status of recent builds.