Your data is your dogfood: DevOps in the astronomical observatory

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ABSTRACT

DevOps is the contemporary term for a software development culture that purposefully blurs distinction between software development and IT operations by treating “infrastructure as code.” DevOps teams typically implement practices summarised by the colloquial directive to “eat your own dogfood;” meaning that software tools developed by a team should be used internally rather than thrown over the fence to operations or users. We present a brief overview of how DevOps techniques bring proven software engineering practices to IT operations. We then discuss the application of these practices to astronomical observatories.

Keywords: IT infrastructure, Software Development, Observatories, DevOps

1. A BRIEF INTRODUCTION TO DEVOPS CONCEPTS

1.1 DevOps

A portmanteau of the words “Development” and “Operations,” DevOps is sometimes mistaken as being simply the principle of having software development and IT operations performed in the same organisational group. In fact DevOps is now a term often used to describe a collection of various techniques, tools and processes that collectively are a set of best practices for modern IT administration.

DevOps is strongly philosophically aligned with the Agile methodology; in fact the movement was conceived as “Agile Infrastructure” or “Agile Operations” prior to the coinage of the term DevOps, and like the Agile methodology, derives from ideas and practices that had been present in the computing field long before then, but had yet to be drawn into a self-identified movement\footnote{An explicit early goal of DevOps was to address the “Wall Of Confusion” with software “thrown over the wall” from development to operations. Differing toolsets used by parties on either side of this wall result in slow and/or fragile deployments, and initially DevOps advocated unifying systems, processes and often people in order to bring the deployment and management under the same agile cyclical process as software development. Partly as a consequence of developing a number of software and techniques in pursuing that goal, and partly by other aligned interests of DevOps practitioners, DevOps is now commonly understood to encompass a number of related technical goals under one umbrella of practice.}

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1.2 Infrastructure as code

The explosive growth in computing infrastructure and the demand for scalability added another dimension to the DevOps approach. The traditional methods of system administration that revolved around dealing with individual machines gave way to automated configuration and deployment systems designed to deal with large numbers of machines at scale, without an administrator having to ever log onto an individual machine. Automated configuration systems such as Puppet\footnote{http://puppetlabs.com} borrow from object-oriented patterns and treat computing resources similar to objects in a class; a machine is no longer a database server, but an instance of a database

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\footnote{The term “Agile Infrastructure” was extant by 2005 and by 2008 had influenced a number of people including Patrick Debois who later coined the term DevOps from a 2009 talk by John Allspaw entitled “10+ Deploys Per Day: Dev and Ops Cooperation at Flickr.”}

\footnote{http://puppetlabs.com}
server class, with its ultimate configuration matching a state described in source code and addressed with normal code-management practices.

The advantages of such a “codification” of IT infrastructure are compelling and include:

1.2.1 Scalability
Once a machine’s desired end state has been captured in an automated configuration system, spinning up 5 or 50 of them becomes merely a matter of procuring hardware resources. The effort associate with either scenario is the same.

1.2.2 Version control
DevOps practitioners typically favour feature-rich version control systems, the most popular being git. The “Infrastructure as Code” approach results in IT configurations being manageable with the same kind of process as traditional software development such as release management via repository branching, the ability to version environments, and easily revert changes. The same benefits accrue: higher productivity with lower technical risk (high-performing DevOps organisations report deploying code 30 times more frequently than their peers).

1.2.3 Agile code quality practices
Other common practices aligned with Agile methodologies, such as unit testing, refactoring, and code review/retrospectives, can be brought to bear to the codified IT infrastructure, bringing many of the same advantages of robustness and versatility (high-performing DevOps organisations report double the change success rate of their peers).

1.2.4 Encapsulation
By pursuing deployment on environments distinct from bare metal, DevOps practitioners have embraced a number of deployment technologies such as virtual machine hypervisors and application containers. Such techniques allow for a more controlled and secure runtime environment.

1.2.5 Disaster recovery
In a DevOps environment the organisation’s IT structure can be replicated on new hardware from just the code repository and application data backups. This is cheaper, faster and more reproducible than restoring from system-level backups. Moreover transitioning a service to different hardware is a simple operation (high-performing DevOps organisations report 12 times faster service recovery than their peers).

1.2.6 Efficiency
The tools in the DevOps arsenal are resulting in unprecedented machines:staff ratio efficiencies. As recently as 2002, IT publications carried articles that said:

Our research indicates that most IT organizations have a system-to-sys admin range of between 10:1 and 20:1. Accordingly, we believe shops with a server-to-sys admin ratio greater than 30:1 can make a good case for additional sys admin staff.

For comparison purposes, Facebook was reporting in 2013 ratios exceeding 20,000:1.

1.2.7 Elasticity of Demand
The emergence of open-source cloud computing platforms such as OpenStack with compatible APIs as commercial web services, allow for a heretofore unprecedented ability to respond elastically to demand; instead of over-provisioning in-house hardware resources to deal with worst-case demand scenarios whilst having them sit idle for periods of trough demand, application instances can be spun up on a variety of additional platforms to service peak demand.

http://git-scm.com
http://www.openstack.org
1.2.8 Team flexibility
By converging the skills required for software development and system administration, the team gains flexibility
in shifting its focus from one area to the other, as project demands fluctuate.

1.2.9 Documentation as Code
IT systems are changeable (and if not, they are ossified, which bears its own risks) and notoriously poorly
documented. One of the advantages in capturing machine state in configuration management systems is that the
code becomes the “documentation” for that system — a reference, guaranteed to be correct, to how the machine
or service is set up.

1.3 Eating your own dogfood
DevOps teams typically implement practices summarised by the colloquial directive urging one to “eat your own
dogfood;” meaning that software chains developed by a team should be used internally rather than with the only
intention to be thrown over the fence to operations, users or customer.

The reason “dogfooding” is a major underpinning of DevOps principles lies both in the DevOps goal of
avoiding the “Wall of Confusion” as well as its Agile-inspired roots. When a development team consumes its
own product, it is far more likely to encounter flaws prior to the release to an operations team. Similarly, the use
of the product within the team allows for the Agile approaches towards it; instead of the goal being “delivery,”
internal use promotes Agile virtues such as introspection, Kanban-like addressing of pain points, and a positive
attitude towards refactoring.

From the technical management point of view, developing directly on the production technology stack reduces
technical risk, speeds up deployments, increases sources of technical support, and makes the cost of change cheaper
— the latter being a critical component of the Agile ethos.

In a way, “dogfooding” results in a development team becoming a stakeholder in its own product.

1.4 Monitoring
With roots in Agile philosophies that value continuous improvement and elimination of bottlenecks, it is un-
surprising that DevOps embraces the generation and monitoring of metrics and associated tools such as log
collectors (e.g., logstash), statistics collectors (e.g., statsd), log analyzers (e.g., kibana), log searching
(e.g., elasticsearch) and dashboard-style visualisation (e.g., graphite).

Goals associated with infrastructure monitoring include:

• increasing service availability
• aiding fault diagnosis
• identifying performance bottlenecks
• improving system architecture

In a DevOps environment, where software development occurs with the same technology stack as production,
these type of metrics can be used to anticipate and fix problems prior to release into production.

http://logstash.net
https://github.com/etsy/statsd/
http://www.elasticsearch.org/overview/kibana/
http://graphite.readthedocs.org
1.5 The One Machine Conundrum

An interesting illustration of how DevOps has “down-evolved” from a set of techniques for large-scale IT systems into a set of toolsets and processes that represent best practice lies in the question: “Suppose you just had a single machine. Would you go all-DevOps on it?”

The answer from DevOps practitioners is frequently “yes,” and it is worth briefly exploring why this is.

There is an erroneous perception that operating a system under DevOps practices is “more work” than old-school system administration, and that these techniques only start paying off at scale. In fact for a practitioner familiar with the tools of the trade, the work of setting up one machine is not in any way excessive, since they would almost certainly already have all the necessary code in their repositories, or could utilise the extensive public repositories of contributed software for common unix administration tasks. More to the point, the effort is simply front-loaded; managing a machine with the DevOps toolset may involve a higher up-front cost, but greatly reduces the downstream cost of managing that machine or service.

From the engineer’s point of view, this allows them to reduce the “background noise” of ongoing machine administration, as many of the functions demanding ongoing attention with traditional system administration practices are tedious, can lead to system fragility, and tend to displace more challenging and rewarding system improvements that increase job satisfaction. In a typical system under configuration management, third-party modules are frequently updated by their contributors to perform any necessary changes in managed packages, further reducing the on-going support effort.

From a project management point of view this is also a highly desireable approach; if one was to see ongoing support of deployed services as a kind of technical debt, front-loading IT activities allows the majority of the effort for administrating that service to be planned, expended, and accounted for in a more constrained period of time, thus reducing downstream effort requirement uncertainties.

It is therefore not the case that DevOps techniques are appropriate only in situations were a single service needs to be scaled, but rather that they provide a way of engineering IT infrastructure, no matter how small or diverse in a way that makes it better suited to software development projects.

2. DEVOPS AND ASTRONOMY

2.1 DevOps and Data Management in Astronomy

The advent of large-scale data science and the evolution of astronomy towards data-intensive experiments such as the Large Synoptic Survey Telescope (LSST) have brought astronomy much closer to the technical space occupied by dotcoms as well as other scientific IT-intensive areas such as particle physics and biology.

On the one hand, it is worth noting the enormous benefits of such convergence, in particular our ability to utilise a great number of well supported, rapidly evolving tools and platforms that greatly increase our ability to manage a data center with the kind of staffing that academic funding allows. For example, at NOAO’s Science Data Management group, we operate a service that includes 0.7 petabytes of GPFS-based storage, a processing cluster, a number of user-facing web and archive services, and our own internal network architecture, on over 100 machines and VMs, with predominantly a single DevOps engineer. The level of technical service that can be provided with modest (though highly-skilled) staffing when leveraging these technologies is unprecedented.

On the other hand, it means that as a field we are operating in the same space as commercial entities able to offer much higher remuneration packages in order to mitigate a skill shortage. It behooves us to create project and organisational environments that are attractive to the highly skilled individuals that we will be needing for our IT activities over the next decade.

It is worth noting that many of us working in astronomical data management are undertaking a number of technically ambitious projects. These projects have IT-centric components, be they software development, observatory operations or archive services, are critical to the success of the scientific goals of the project, and the science value that is returned for public investment. Paying due care to running our IT infrastructures within the scope of proven best practices, and aspiring to the technical drive and efficiency that is characteristic of the
more successful young technology companies, would be a significant contribution to the success of the projects we serve.

Our users are, after all, operating in the same technological environment; it will become increasingly difficult to convince an astronomer that they have to wait a day for an IT service that they could help themselves to in a few minutes with access to a cloud service provider and a credit card. As our users become more accustomed to self-servicing their IT needs, it becomes more important that archive centers step up to that kind of level of service, or risk being sidelined by our more motivated users.

2.2 DevOps and the Observatory as a whole

While DevOps as an umbrella of practices focuses around software development and IT infrastructure, as a philosophy it has a relevance to the kind of wider range of technical and scientific work that takes place in modern astronomical observatories.

Our observatories are often characterised by functional silos, not only at the science, hardware, software level (a division that is to the authors’ knowledge ubiquitous), but more problematically within the software level (telescope, instrument, data reduction, archiving).

Jez Humble writes:

The DevOps movement addresses the dysfunction that results from organizations composed of functional silos. [...] DevOps proposes instead strategies to create better collaboration between functional silos, or doing away with the functional silos altogether and creating cross-functional teams (or some combination of these approaches).

Unsurprisingly, we see examples of the “Wall of Confusion” with every one of those silos: The instrument throws the data over the wall to the data reduction which throws the data over the wall to archiving which throws the data over the wall to the user. If the telescope pointing is poor, it has to be corrected in data reduction; if the observing system cannot reliably capture data ownership information, this has to be fixed by archiving; and so on. Whenever a problem has to be addressed in a different functional silo than the one in which it originated, the fix becomes less accurate and far more expensive.

We could benefit from applying some of the DevOps approaches to dealing with these walls: unified cross-functional groups, common toolsets and platforms that allow people to self-serve their needs, metrics that identify improvements that are fed back into the groups that can do something about them. Indeed, one can argue that where many observatories are over-committed or under-funded, the lean operations model facilitated by cross-functional, wide-skilled software teams becomes compelling.

2.3 Why our data is our dogfood

The one thing that practically everyone in an observatory “touches,” in one fashion or another, is the data. So if we look to eat our own dogfood, we have to look at how we can increase internal “consumption” of our data products.

There are a number of ways we could use data to erode the boundaries between our functional silos. Some of them are:

- Engineering functions are usually poorly served by the scientific data flow. In fact there is little reason not to include more metadata of engineering interest in data files, and use monitoring tools to provide dashboards of quantities of interest (e.g., image quality) that are derived in data processing.
- There is metadata that is of interest to the science user that can be captured in the data too, such as weather information, or at least associated and published with it in a robust fashion.
- It is possible for the archive to collect not only data, but time-based information that is of interest to the science user. For example, the information that there was an engineering problem that may have affected data quality on the night the dataset they are interested in was taken.
• Create richer, self-defined data formats and reference libraries to access them in order to make data analysis tools useful to a wider range of technical and scientific staff.

• Use DevOps tools and platforms so that observatory or science collaboration software can be easily deployed at archive centers, user institutions, or the cloud.

Treating the data flow as a link between all stakeholders of the observatory, almost like an API between the telescope/instrument and the astronomer, becomes even more important as a significant fraction of science is being done from public data accessed from archives by astronomers with little knowledge of the originating facilities.

Perhaps developments in such a direction will also be a positive direction towards the greatest silos of all: different observatories. Our field has long bemoaned the low rate of software re-use in astronomy due to a constant re-invention of the wheel, which has held us up as a discipline. Perhaps as we standardise on current development techniques, lower barriers to software changes and adopt flexible deployment practices, we can work as a community towards the kind of software sharing and continuous progress that we have witnessed in the open source community. Initiatives such as the Astrophysics Source Code Library and moves by observatories, such as Pan-STARRS, LSS and CCAT to open-source and publicly host their software development from the beginning, are steps in the right direction.

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