# Unifying Workflows for UFS Applications

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## Stakeholder Institutions

NOAA EMC
GMU
CIRES
NOAA GSL
NCAR RAL
DTC
JCSDA
NOAA PSL


*PI9 team

# What is UFS?

*The Unified Forecast System (UFS) is a* ***community-based***, ***coupled***, ***comprehensive*** ***Earth modeling system***. *The UFS numerical applications* ***span local to global domains*** *and* ***predictive time scales from sub-hourly analyses to seasonal predictions***.

# What is UFS?

*… applications share agreed-upon numerical forecast system elements, including Earth-system model components (e.g. atmosphere, ocean, sea ice, land, chemistry, etc.), observation processing, pre-processing, data assimilation, forward forecasting, ensemble and probabilistic processing, and post-processing…[and] infrastructure such as model coupling tools and workflow software.*

**We all run the same components, configured in different ways**

# The Big 3+ Apps

MRW
Medium-Range Weather

HAFS
Hurricane Application

SRW
Short-Range Weather

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Land DA

Total Coastal Water

RnR
Reforecast & Reanalysis

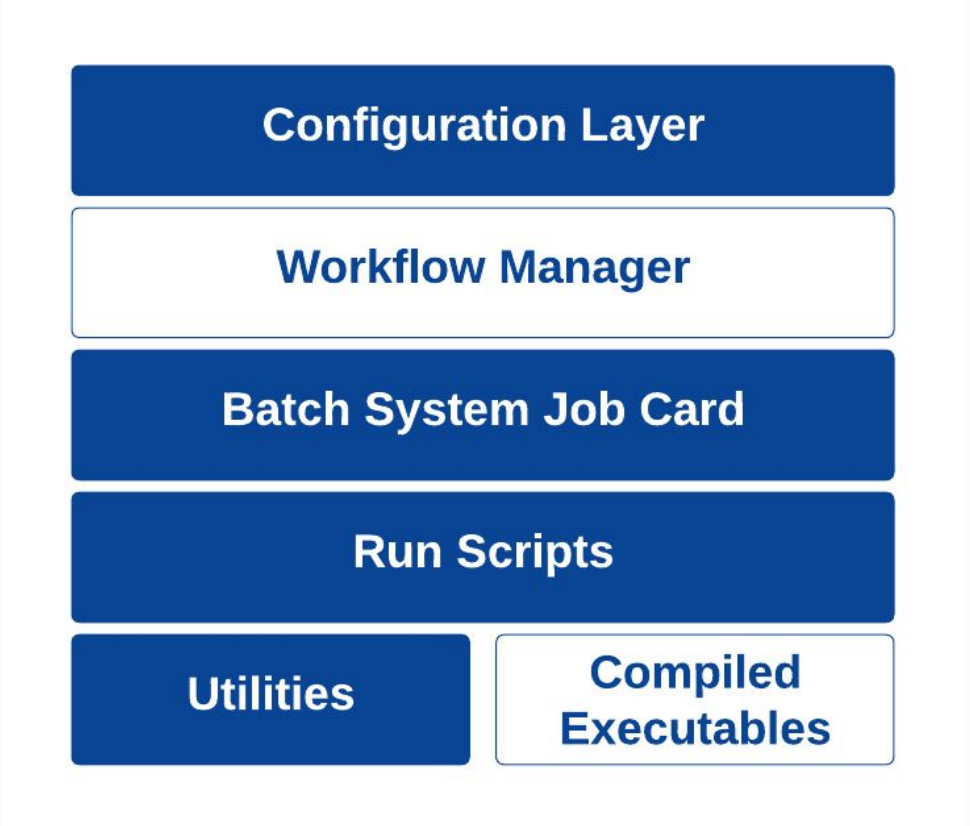
Exascale Prototypes

S2S
Subseasonal-to-Seasonal

Atmospheric rivers

# Current system architecture

## Operational standards dictate a layered structure



# UW Team Vision

Build a **modular**, **portable**, **robust framework** for running the Unified Forecast System that supports research and operations

Take a **services-based approach** to ensure extensibility and usability by all of the UFS Applications

Develop a **user-interface** that the UFS Community can be comfortable using

# UW Team Goals

**Obtain more funding** at a variety of institutions to join the UW Team

**Ensure buy-in from NOAA leadership** in charge of each App and Operations so that UW software can make it through the research funnel

**Regularly release tools** for inclusion in Apps to start iterative design process early

**Apply software best practices** to ensure a robust, well-tested, easy-to-use toolbox and framework for UFS workflows

# Unification Strategy

## Short Term (Upcoming PIs)

Develop a set of generic, **standalone tools** to address common high-maintenance problems.

Propose the changes necessary in the relevant UFS Apps and components.

## Medium Term (Upcoming year)

Replace the configuration layer of the existing Apps with a **framework** that unifies them around a **service-oriented architecture (SOA)** to achieve a “plug and play” feel for a given experiment.

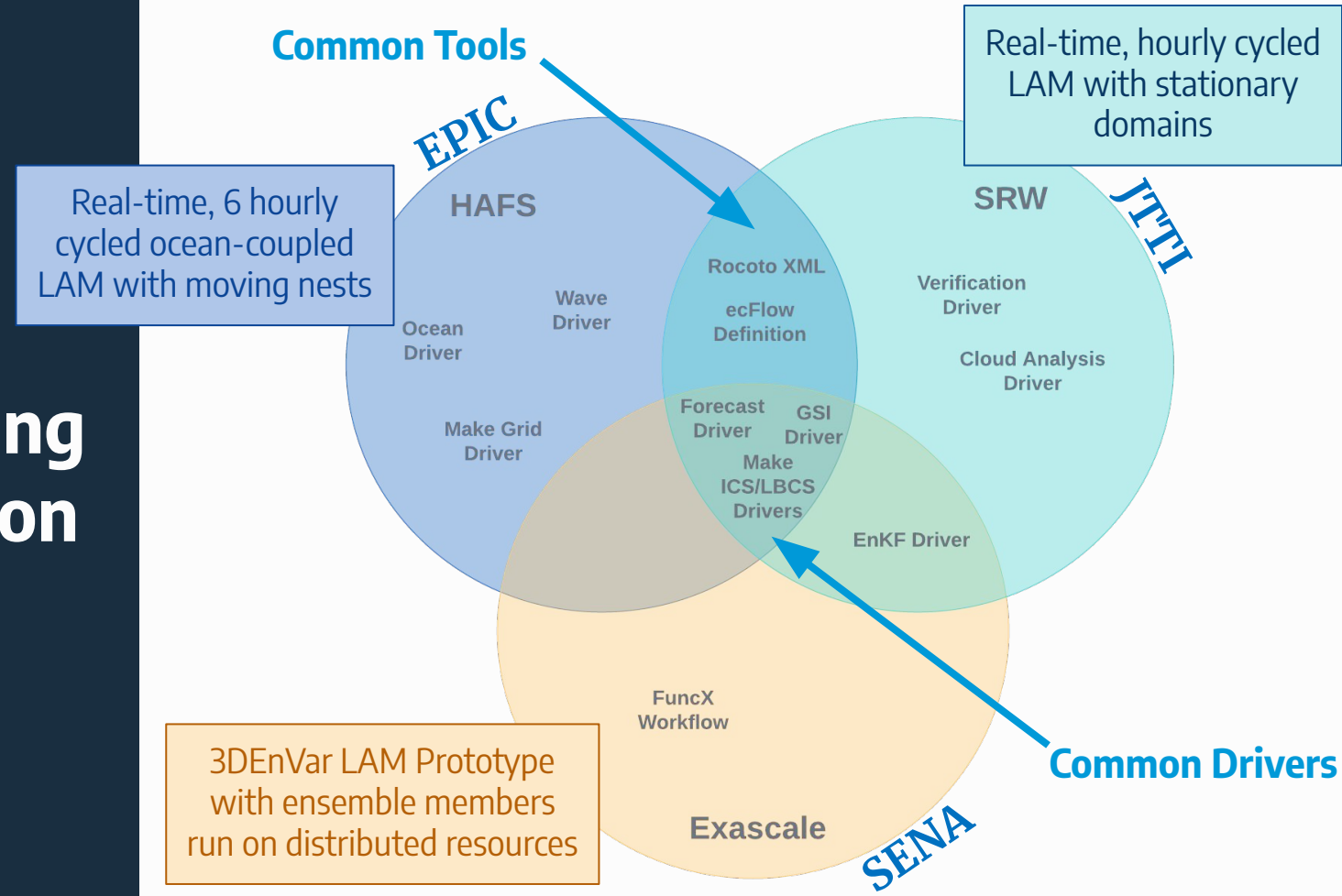
Requires developing necessary interfaces to the existing component drivers (e.g., bash run scripts) and existing workflow managers (e.g., ecFlow, Cylc, Rocoto).

## Long Term (Next few years)

Use the SOA framework as a facade and apply the **strangler pattern** to gradually replace and unify the underlying component drivers.

**Unify gradually, iterate often, add value ASAP.**

# Prioritizing Unification





# Standalone Tools

# Tools for Standalone Release

## Configuration Management Tools for the UFS Weather Model

- Currently there are ~10 different types of parameter files the model uses to generate a forecast.
- These tools allow all parameter files to be managed from a single YAML configuration file
  - Improves organization, readability, and understanding compared to bash variables
- The tools will allow the Apps to use the parameter files (e.g., namelist, model_configure, etc.) directly from the model regression tests
  - Decouples the weather model version from the workflow
  - Promotes increased compatibility between the workflow and a variety of model versions
  - Reduces manual, repeated code maintenance when updating to a new version of the model (Apps usually keep a *copy* of these files in their own repositories, which is not ideal)
- A Python-based approach opens new doors for configuration validation (planned for future releases)
- The basis for the Unified Workflow configuration system

# Tools for Standalone Release

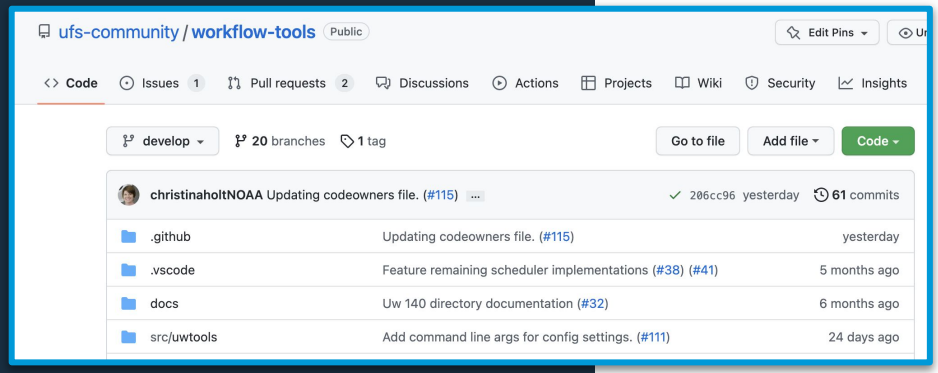
## ecFlow and Rocoto Interfaces

- Takes in a YAML configuration file defining workflow
- Processes the information such as
  - Task resource requirements
  - Dependencies and triggers
  - Run-time environment
- Writes out necessary workflow definition files
  - Rocoto XML
  - ecFlow Suite Definition
  - ecFlow Job Cards
  - Standalone wrappers
- Dynamic and automatic at the time of experiment creation
- Tool is uncoupled to the experiment definition

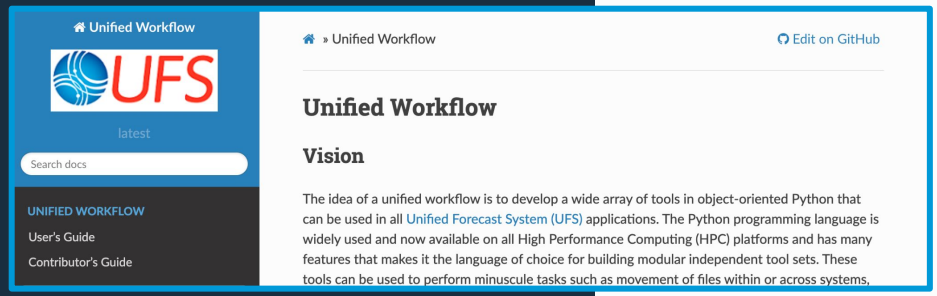
# Tools for Standalone Release

## File Mover

- Moves files between various locations
  - Cloud block storage, local file systems, HPSS, URLs
- Alongside a database of known data stores, this tool will help users stage the data they need as part of any workflow
- Enables users to work with data on various platforms with the same interface.
  - Local copies can have very similar commands as remote copies from a URL, for example.
  - Reduces overhead for understanding Python syntax and caveats for equivalents to cp, sync, wget, aws cli, and others.




# Stay in the loop




## GitHub Repository

https://github.com/ufs-community/workflow-tools

## GitHub Wiki

https://github.com/ufs-community/workflow-tools/wiki

## GitHub Discussion

https://github.com/ufs-community/workflow-tools/discussions

## Read the Docs

A Contributor's Guide and User's Guide

https://unified-workflow.readthedocs.io/en/latest/

# Questions?
# Suggestions?

Contact:
Christina Holt, christina.holt@noaa.gov

# Backup Slides

# A SOA Unified Framework

What is **Service-oriented Architecture** (SOA)?

- A service is **software component** that provides some functional capability
- Services can **communicate with each other** and across platforms and languages
- Services can be **reused** in different systems
- Multiple services can be **combined to perform complex tasks**

https://aws.amazon.com/what-is/service-oriented-architecture

# SOA is a design pattern

**Not to be confused with SaaS – Software as a Service.**

SOA is an **architectural approach** that can be applied to the design and development of various types of software systems, including enterprise applications, distributed systems, and integrations between different systems

SOA is a broader concept that **encompasses the design principles, patterns, and practices** for building modular, interoperable, and scalable software systems based on services.

**SOA is *exactly* what we need for unification!**

# Unified Framework Services

What are **services**?

Chunks of code that should:

Be **independent** – changes to one service should not impact other services

Be **fully interoperable** – it doesn't matter which App is running it

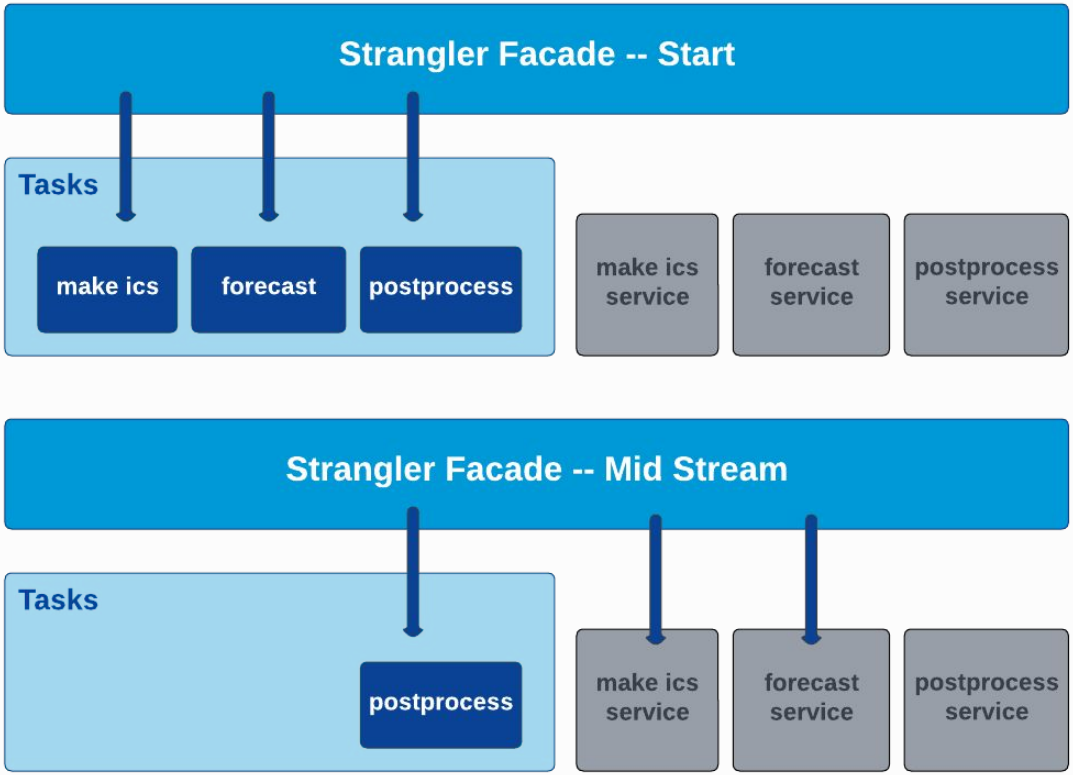
Be **loosely coupled** and **stateless**

Be **responsible for one thing**

Employ **standardized communication protocols**

https://aws.amazon.com/what-is/service-oriented-architecture

*Strangler* isn't as bad as it sounds




https://www.redhat.com/architect/pros-and-cons-strangler-architecture-pattern

# Not to be confused with SaaS

## Software as a Service

SaaS is a cloud computing model where software applications are **provided over the internet**, and **users access them through a web browser**.

With SaaS, **users don't need to install or manage software locally**, as the applications are hosted and maintained by the service provider

**SaaS is NOT where we're going with unification!**



# Unification Approach

# *Strangler* isn't as bad as it sounds

The pattern is named after the Strangler Fig plant, which grows around a host tree and gradually chokes it, eventually replacing it entirely.


The *Strangler*, or *Strangler Fig* Pattern is a software design pattern that involves **gradually replacing an existing system** with a new one, using the old one as a foundation.

# *Strangler* isn't as bad as it sounds

## Pros

The end user interface is **delivered early** in the process

**Reduces risk** when modernizing monolithic systems

Does *not* require a complete system overhaul on Day 1

A service transition **could be rolled back** if something goes wrong

Provides the development team ample time to **iterate on the system implementations** – what works and what doesn't.

All UFS Apps are *not* required to be on the same schedule

## Cons

There may be **many interfaces** needed in the facade

Requires a *lot* of ongoing **attention to changes** occurring in both the original system and the facade

It's **hard** to modularize components that are tightly coupled

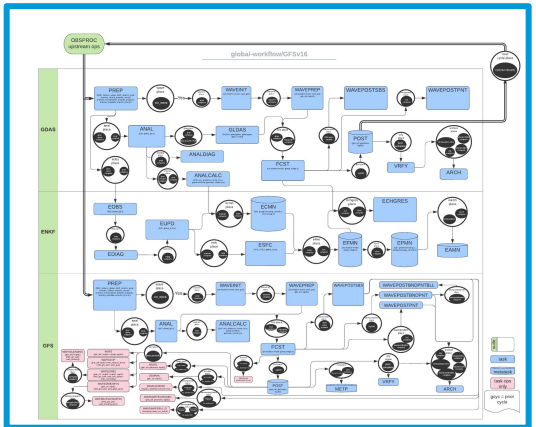
https://www.redhat.com/architect/pros-and-cons-strangler-architecture-pattern

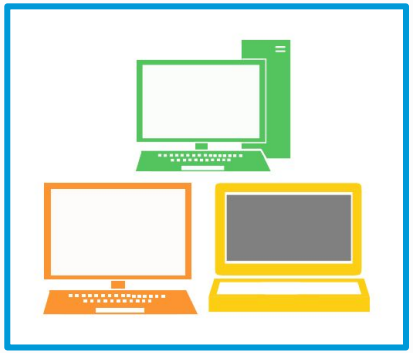
# Decoupling the subsystems

# Configuration Subsystem

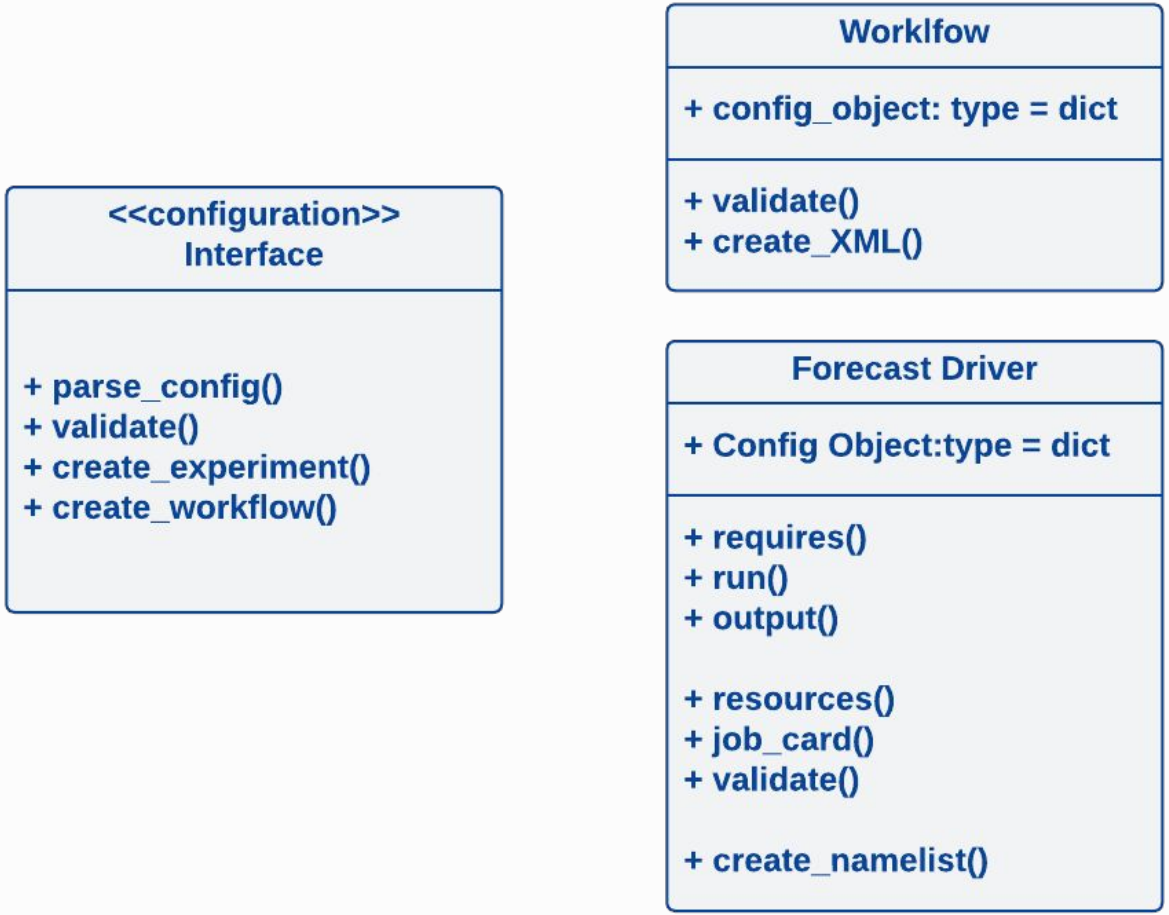
Responsibilities include:

- Gathering user provided parameters
- Managing default settings for all portions of the System
- Validating that settings are appropriate and compatible
- Creating and populating experiment directories with experiment-specific files and data
- Optionally, starting the workflow manager of choice.



# Component Drivers as Services



# Summary

WHY:

## Too many tightly coupled workflows for UFS

WHAT:

## Building a Unified Framework

**Standalone Services & Service Oriented Architecture Pattern**

HOW:

## Taking a Strangler Approach

**Replace existing components gradually**