Networked Environment for Music Analysis (NEMA)

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The iSchool at Illinois

Credits and Acknowledgements

- Funding Provided By
  - Andrew W. Mellon foundation

- Co-authors
  - Kris West, Amit Kumar, Guojun Zhu, J. Stephen Downie, Andreas Ehmann, Mert Bay

- IMIRSEL
  - **I**nternational **M**usic **I**nformation **R**etrieval **S**ystems **E**valuation **L**aboratory
  - The goal of the IMIRSEL is to advance the state-of-the-art in Music Information Retrieval research

Agenda

- Definitions
- Background
- Project Goals
- Implementation
  - MIR Tasks as Workflows
  - User Interface
  - Workflow Processing
  - Remote Executors
  - Job Results
- Future Directions

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Def nitions

- **MIR**
  - Music Information Retrieval
- **MIR Task**
  - A specific, well-defined MIR problem, for example:
    - Artist Identification
    - Mood Classification
- **Music Collection**
  - A large body of audio tracks from a common source
- **Dataset**
  - Datasets aggregate sets of audio tracks, metadata about the tracks, and machine learning parameters needed to execute a particular task.

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Collection Access Restrictions

- Copyright restrictions prohibit sharing of large music collections between researchers
- Licenses are prohibitively expensive
- Use of creative commons collections is not a good solution
  - Small scale collections
  - Widespread use within the MIR community leads to overfitting of models

MIREX

- Music collections challenges led to the establishment of MIREX
  - **M**usic **I**nformation **R**etrieval **E**valuation e**X**change
  - An annual competition since 2005
- Researchers submit (to IMIRSEL) MIR algorithms to be *manually* executed against large music collections, and evaluated using standardized measures
- MIREX drives MIR research by encouraging the community to define new tasks, algorithms and evaluation procedures
- MIREX has required enormous effort by the IMIRSEL team in the execution, debugging, and validation of submitted code

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Project Goals

- Service-oriented infrastructure for the submission and *automated* execution of MIR compute tasks
- Movement and execution of arbitrary, user-submitted code
- Support heterogeneous execution environments
- Support the use of distributed music collections
- Enforce security of music collections
- Promote sharing of techniques and algorithms

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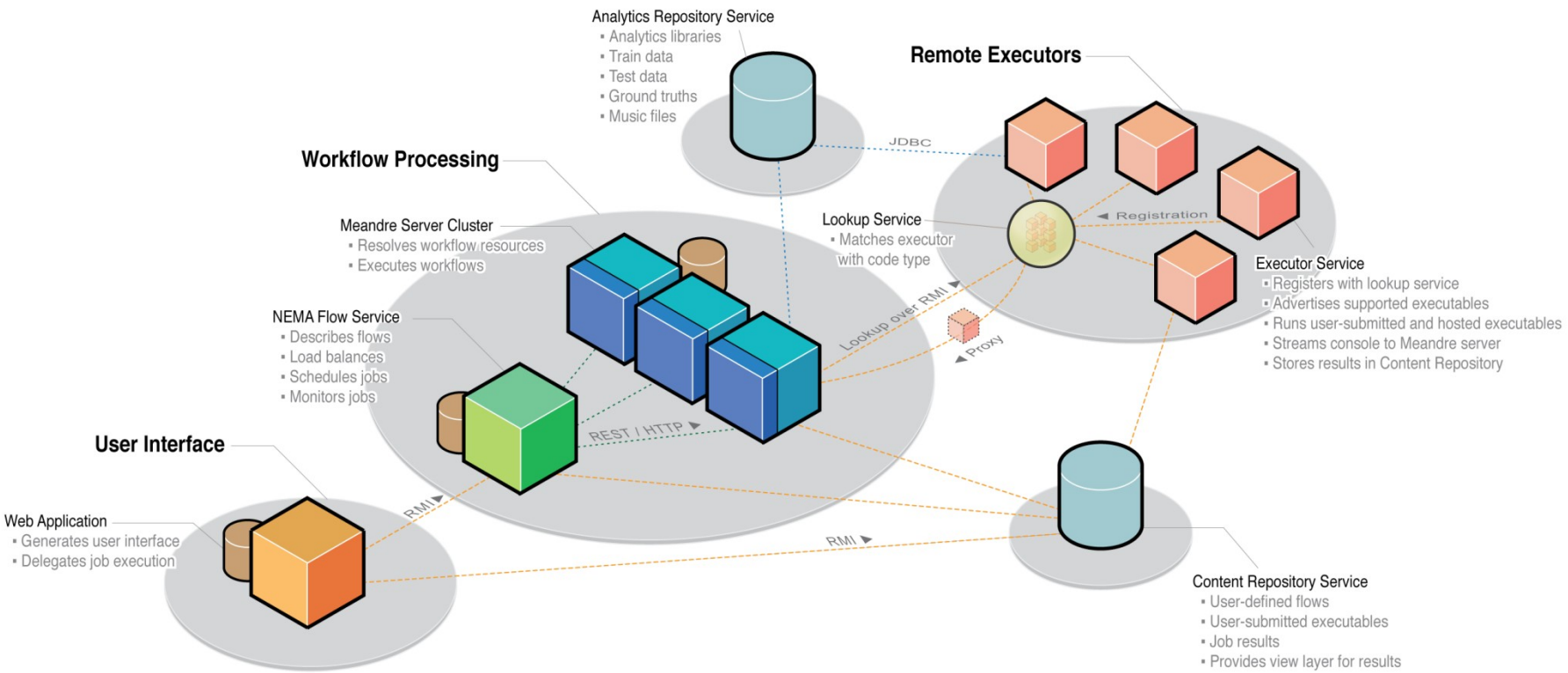
NEMA System Overview (Logical)



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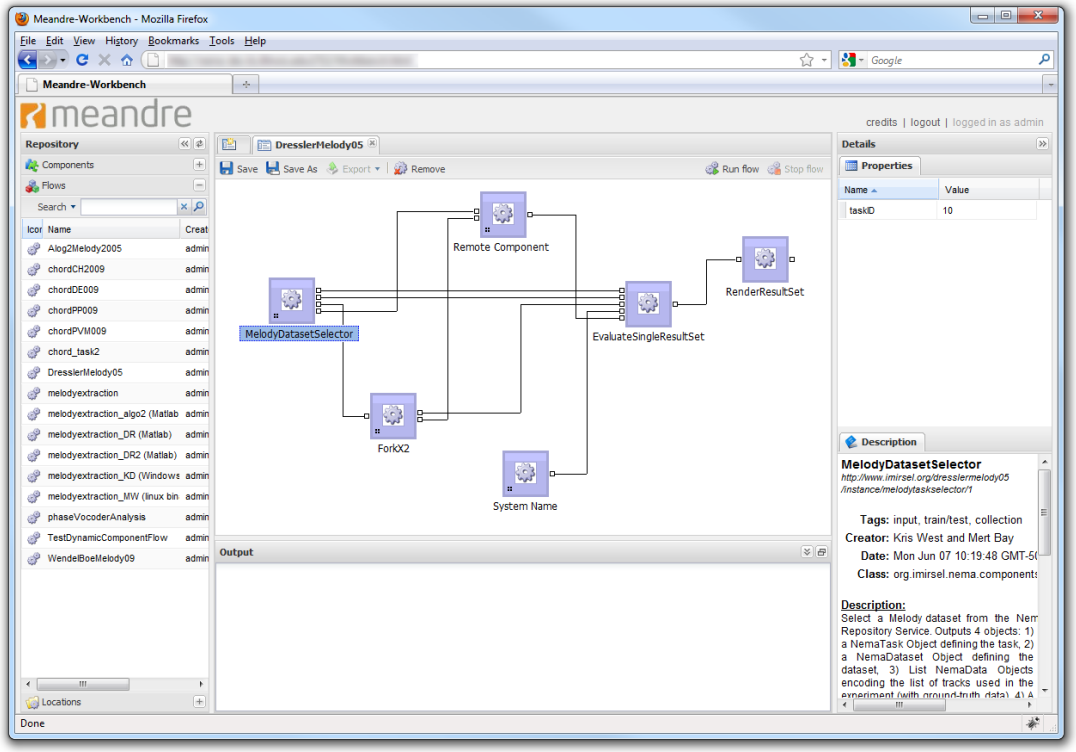
Tasks as Workflows

- MIR tasks can be broken down into discrete units of work
  - Task "components"
  - e.g. dataset selection, dataset analysis, result evaluation
- Component execution can be delegated to remote executors to satisfy collection access restrictions
- Workflow-based computing facilitates repeatable experiments and valid comparisons between runs

Meandre

- NEMA uses Meandre (NCSA) to implement its workflow processes
- Meandre provides basic infrastructure for creating and executing flows
- RDF-based models for executable components, flows, and repositories
- Meandre Workbench for visually wiring together components to create flows
- Meandre Server for executing flows



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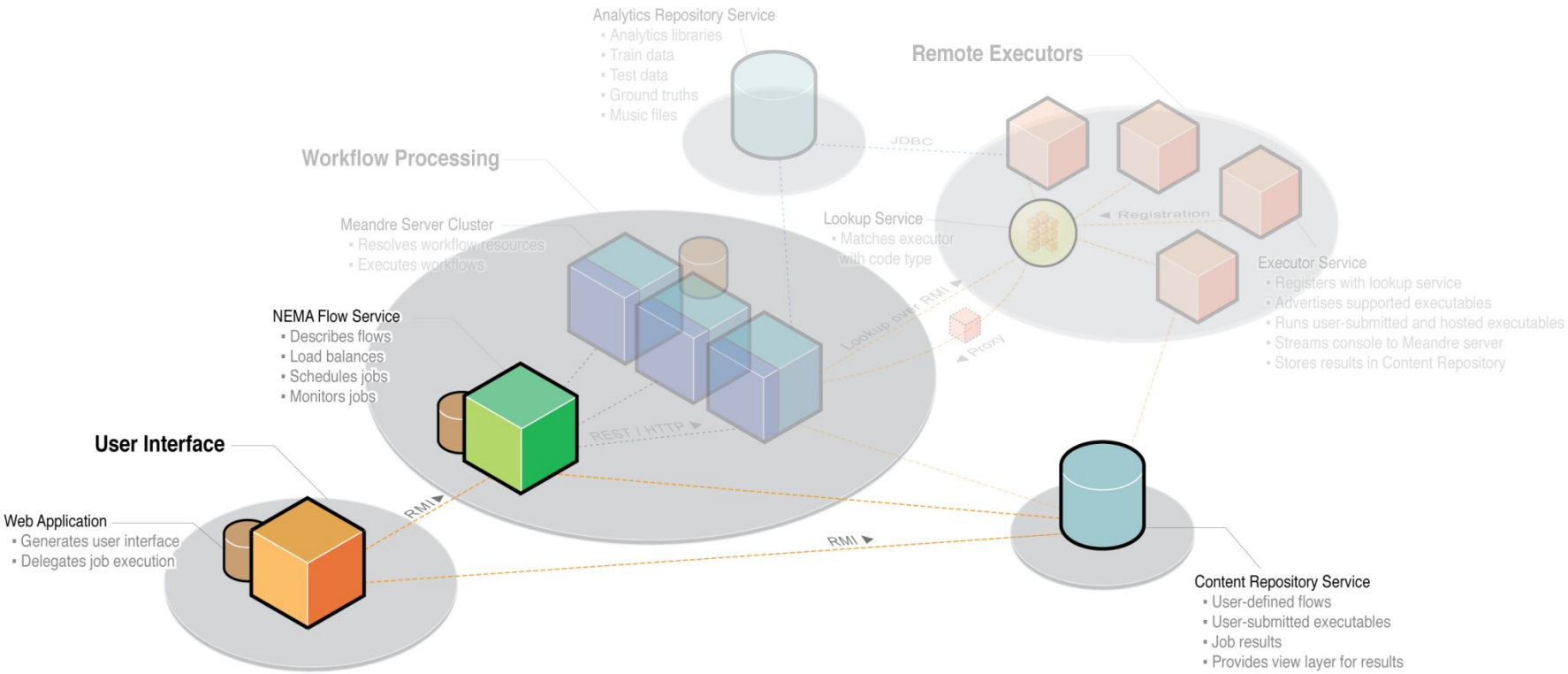
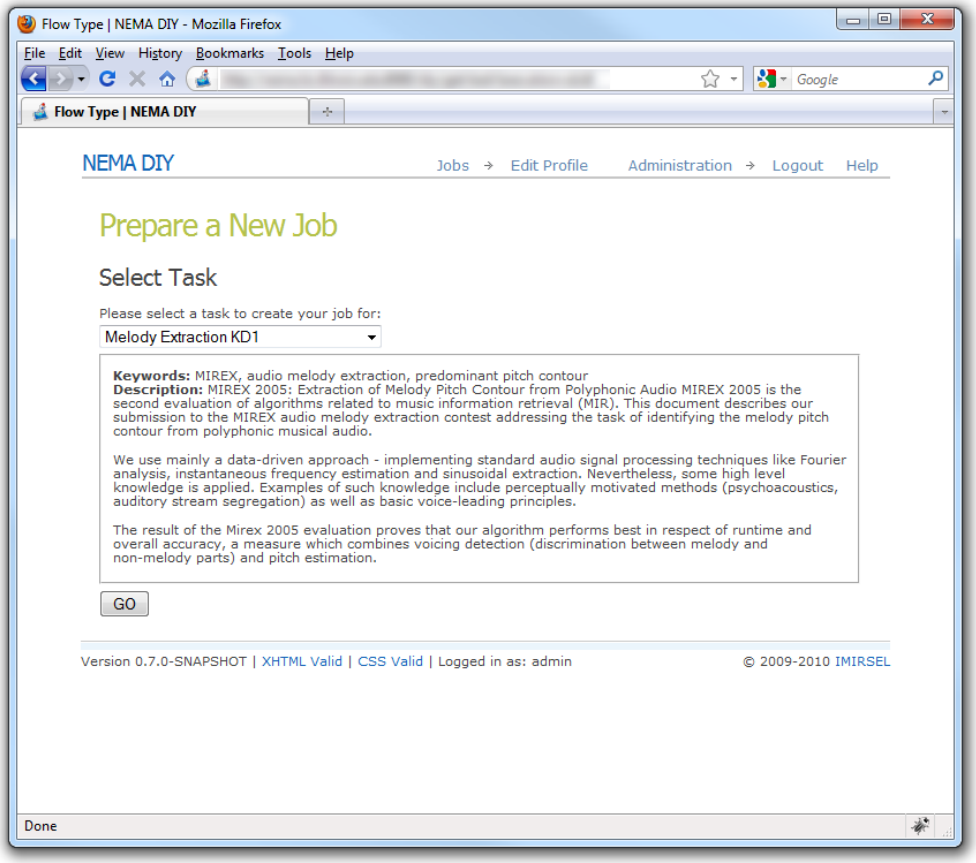
User Interface



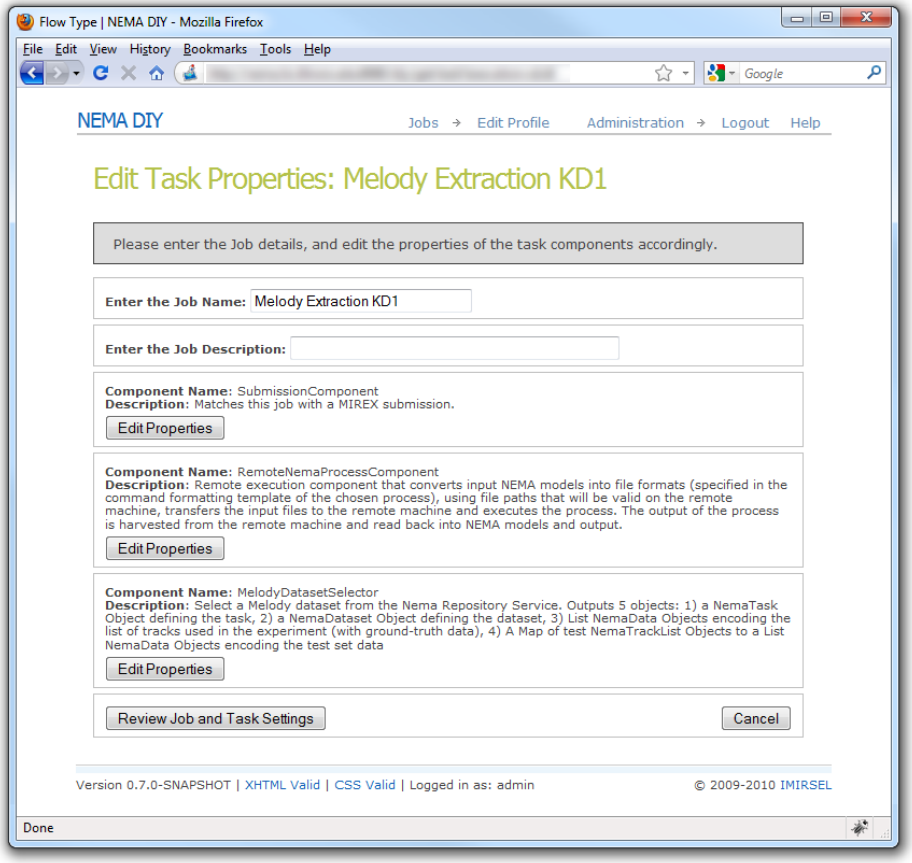
Selecting a Task

- Users select from the list of available MIR tasks in order to run a new job
- "Task templates"
- Each task template corresponds to a flow in our central Meandre repository



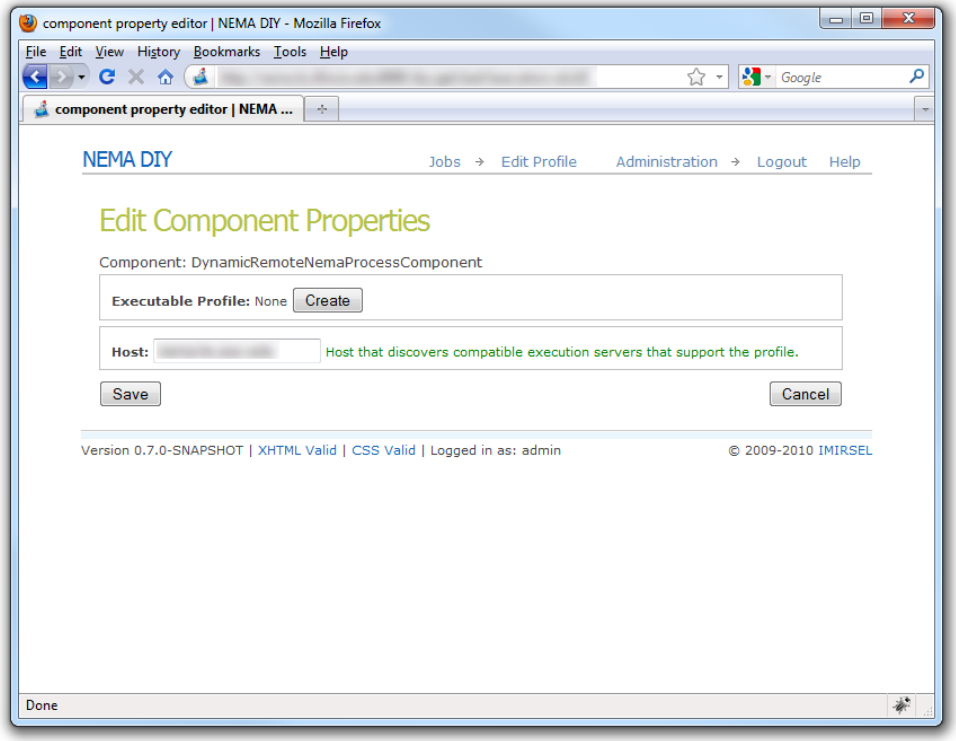
Conf guring a Task

- NEMA Flow Service is queried for the components that make up the flow
- User edits component properties to configure the flow instance



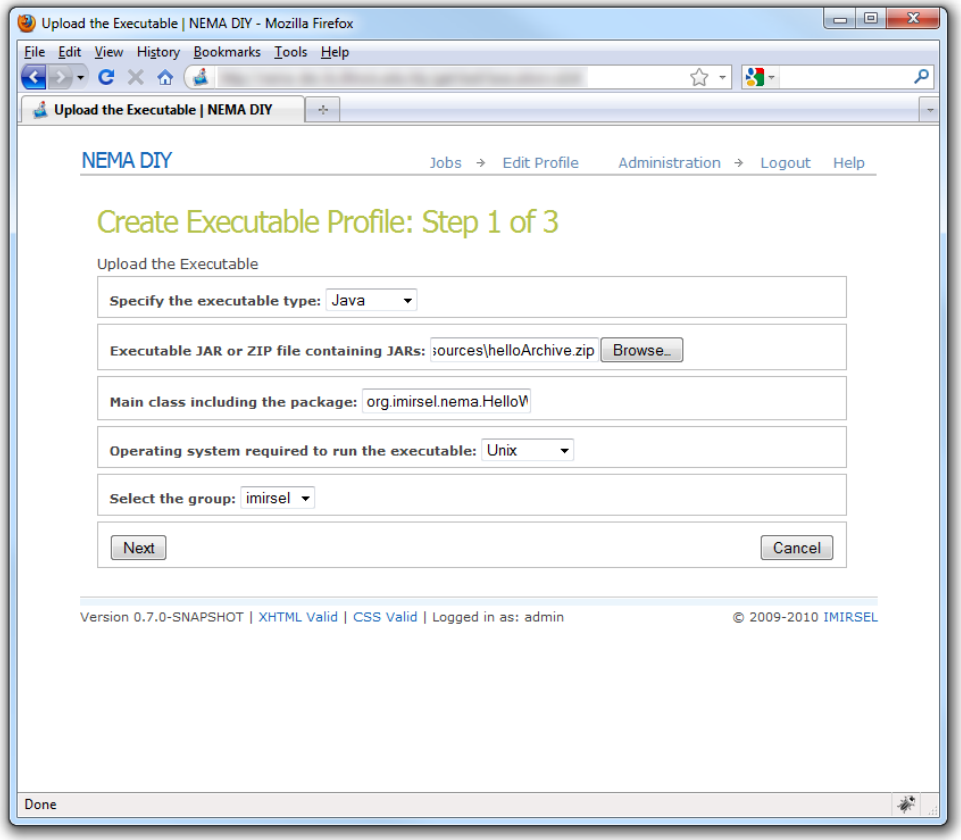
Conf guring Remote Components

- Shown is a “Dynamic Remote Component”
- The “Executable Profile” property fully describes the executable that needs to be run
- The “Host” property specifies the address of the remote executor lookup service



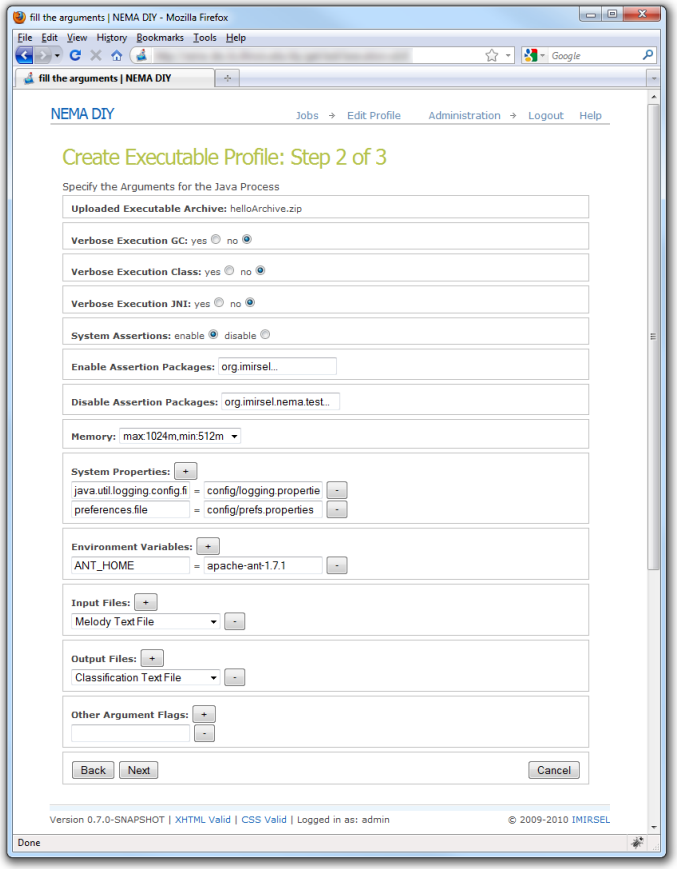
Conf guring Remote Components

- User-submitted executables can be coded in Java, MATLAB, Binary (C, C++, etc.), Perl, Python, Wine, Shell or Ruby
- User uploads an archive containing the executable entry point, supporting libraries and resources



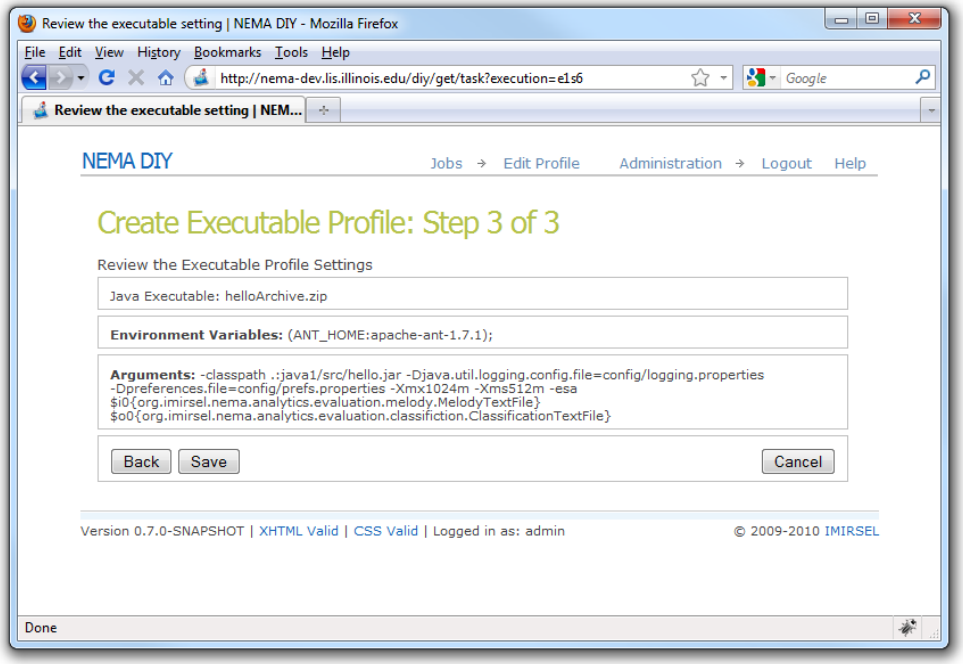
Conf guring Remote Components

- After uploading the executable, the user can supply further configuration information
  - System properties
  - Arguments
  - Environment variables
  - Input & output file formats



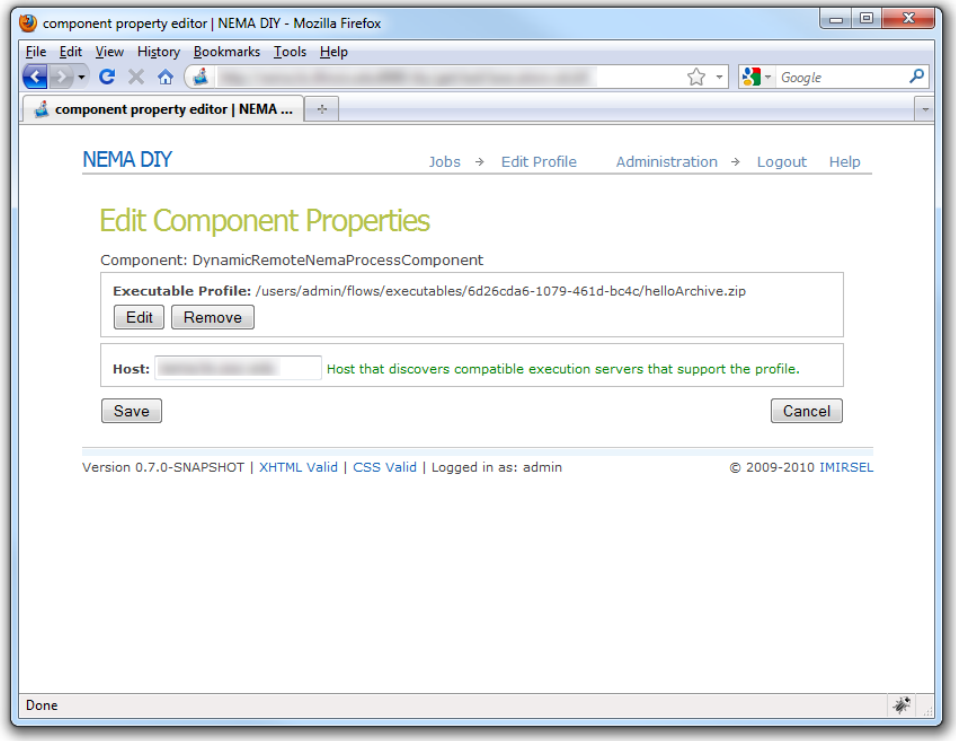
Conf guring Remote Components

- A preview of the complete executable profile is displayed prior to submission
- When a save is triggered, the completed profile is persisted to the remote Content Repository Service



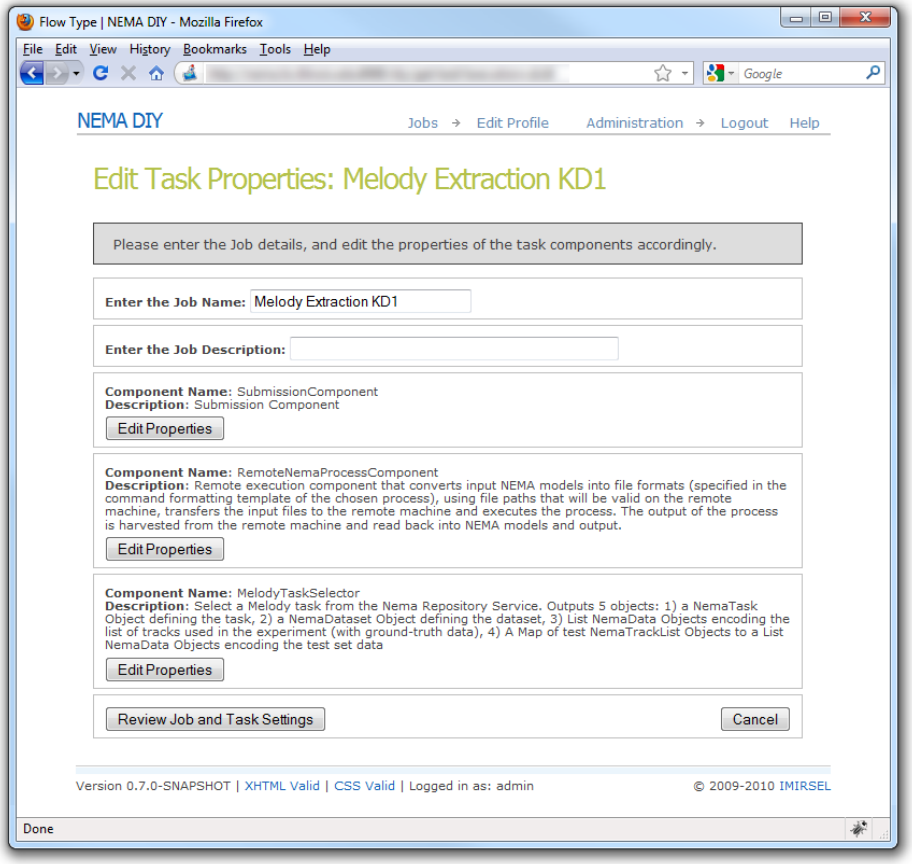
Conf guring Remote Components

- The “Executable Profile” property is now populated with the location of the profile in the Content Repository



Submitting Jobs

- After the user submits a job for execution, the web application creates a new "flow instance" preserving the user-configured flow state
- The web application then issues a job request to the Flow Service with a reference to the new flow instance



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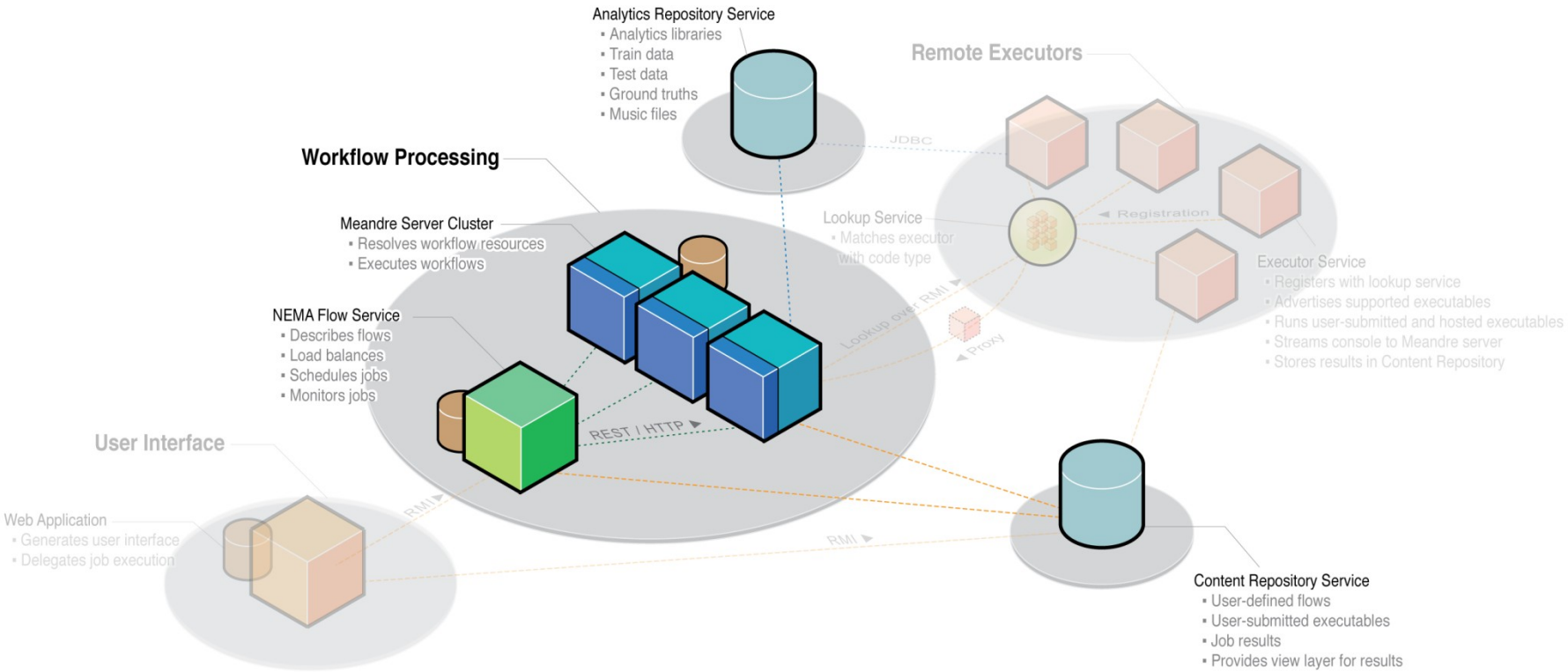
Workf ow Processing



Flow Service

- Abstraction layer between UI and Meandre Servers
  - Java application w/RMI service interface
- Implements functionality for:
  - Load balancing
  - Job execution
  - Job monitoring
  - Job status notifications
  - Server monitoring
- Also provides operations for:
  - Describing installed NEMA flow templates
  - Describing components and properties

Meandre Server

- Provides a RESTful web service API
  - Operations for adding, querying & removing:
    - Repositories, components & flows
  - Operations for running and monitoring flows
- NEMA Meandre Server cluster
  - 1 head node
    - Flow Service uses for querying flows & components
  - N worker nodes
    - Flow Service uses for job execution

Meandre Server

- Meandre repositories, components and flows are stored in RDF
  - Independent repositories can be dynamically merged
  - Flows may refer to components that reside at different URLs on the web
- Execution-time component resolution
  - Given a flow model to execute, Meandre will resolve the components at runtime

Datasets

- The dataset, along with the larger NEMA data model, supports all MIR scenarios experienced with MIREX
- Other key objects used in our flows are contained by, or derived from, datasets
  - Audio tracks
  - Track metadata
  - Training and testing sets
  - Ground truths
  - Machine learning parameters
- Datasets contain paths to the physical audio tracks

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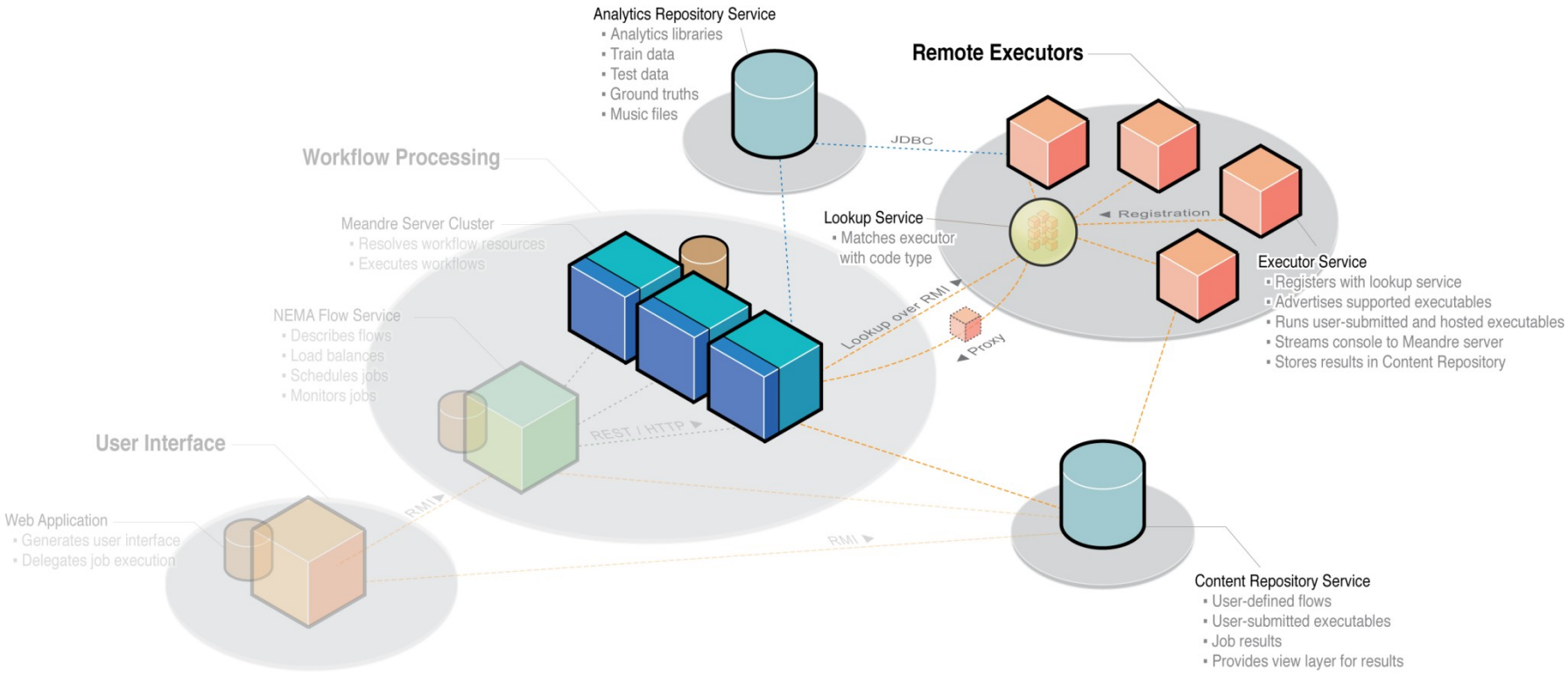
Remote Executors



Remote Executors

- Client side
  - Implemented as a Meandre component
  - Gets the executable profile stored in the Content Repository
  - Queries the lookup service for Remote Executors capable of running the executable
  - Delegates processing to the Remote Executor
  - Remotely monitors process lifecycle, output/error streams, and process results

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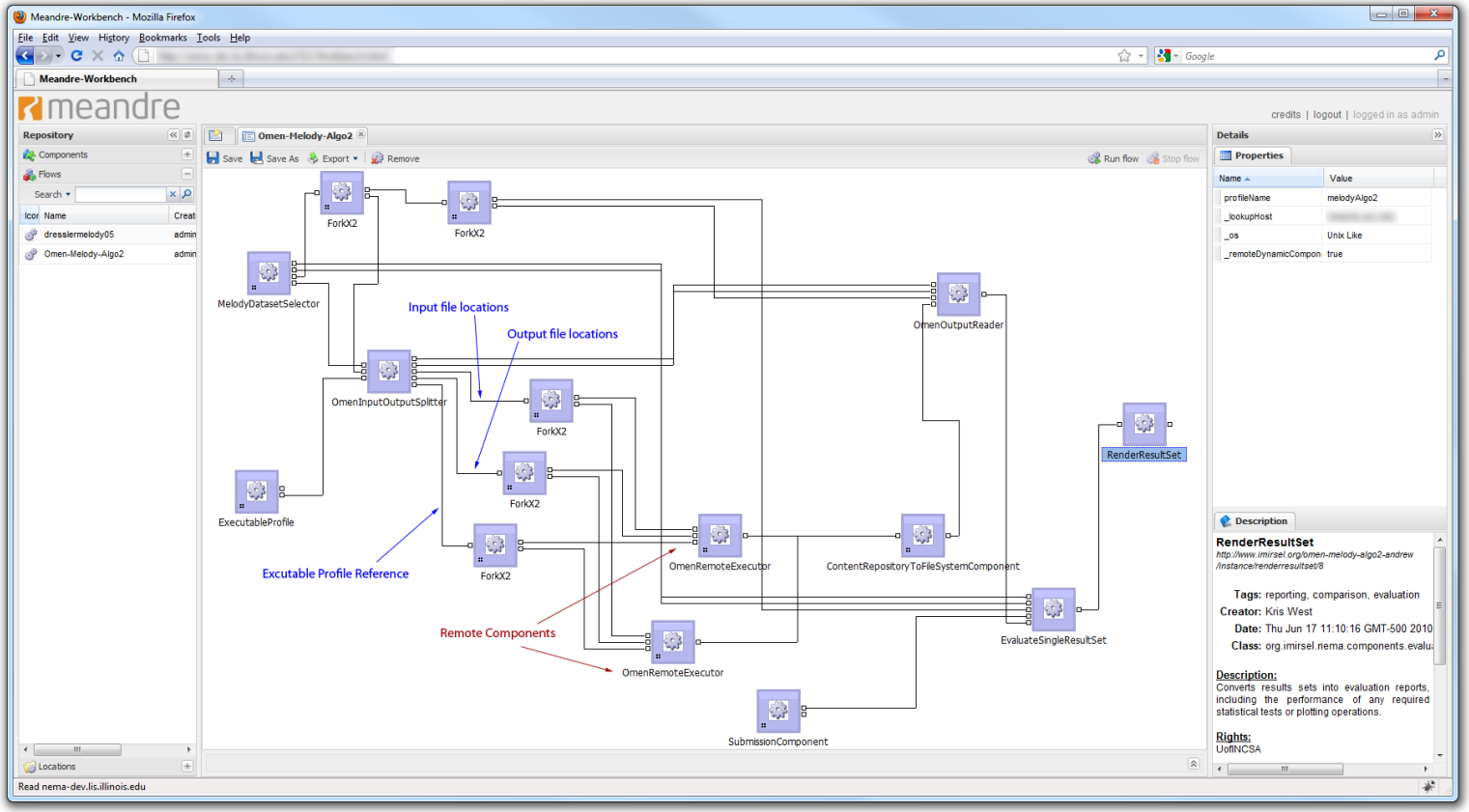
Remote Executors

- Service Side (placed at the data)
  - JINI-based service
  - Registers itself with the lookup service
    - Advertises supported executable types, host OS, etc.
  - For dynamic executables, downloads executable archive from the Content Repository Service
  - Queues process requests if server is already processing maximum number
  - Runs processes using Java ProcessBuilder class
  - Stores results in the Content Repository Service

Multiple Remote Executors



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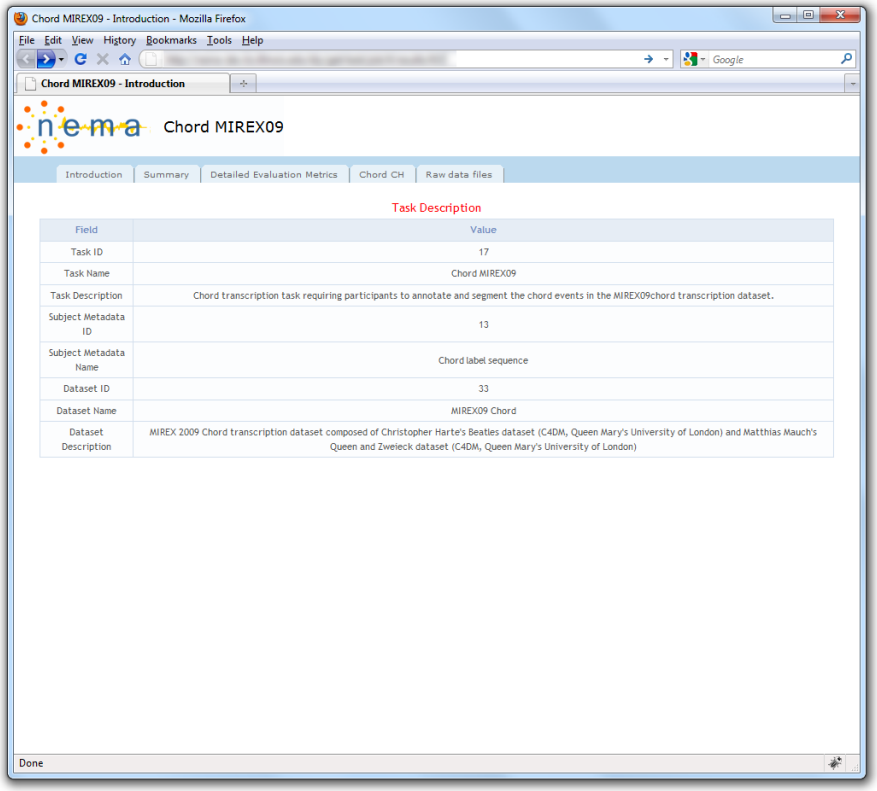
Job Results

- Results are generated by user code in a format specified in the executable profile
- Remote Executors save results to the Content Repository
- Downstream components, running on the Meandre Server, copy the results locally for use by an evaluation component
- After the evaluation component runs, a report is generated that summarizes the evaluation

Evaluation Reports

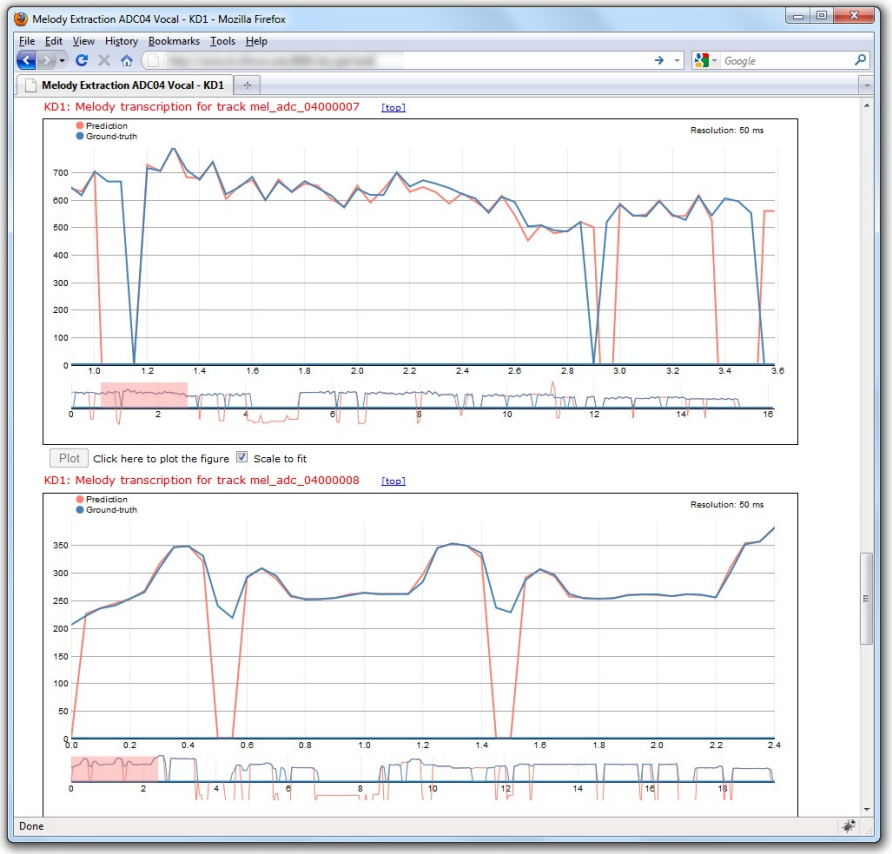
- Evaluation reports are made available in the UI along with other job details
- Shown is a chord transcription report



Field	Value
Task ID	17
Task Name	Chord MIREX09
Task Description	Chord transcription task requiring participants to annotate and segment the chord events in the MIREX09chord transcription dataset.
Subject Metadata ID	13
Subject Metadata Name	Chord label sequence
Dataset ID	33
Dataset Name	MIREX09 Chord
Dataset Description	MIREX 2009 Chord transcription dataset composed of Christopher Harte's Beatles dataset (C4DM, Queen Mary's University of London) and Matthias Mauch's Queen and Zweleck dataset (C4DM, Queen Mary's University of London)

Evaluation Reports

- Melody extraction result plots
- Each plot represents the system's performance for a single song in the dataset
- Blue lines are ground truth
- Pink lines are predictions
- X axis is time in seconds
- Y axis is frequency in Hertz



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Future Directions

- Additional partner collection sites
- Integration with myExperiment
- UI improvements
- User-configurable VMs
- Year-round access

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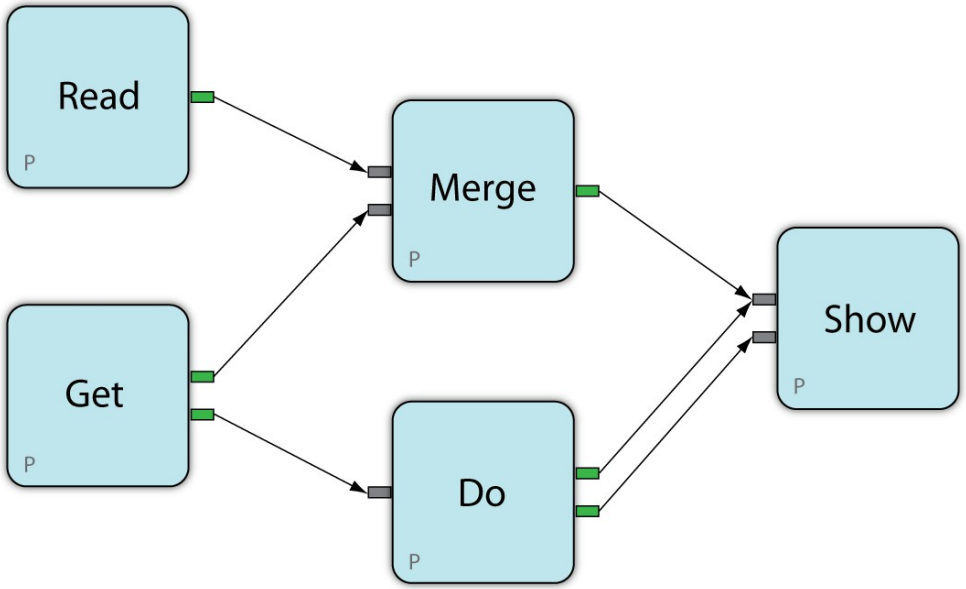
Thank you

- For more information:
  - Andrew Shirk
  - shirk@illinois.edu

Tasks as Workflows

- A task is a collection of connected components with inputs, outputs and configurable properties



Meandre Repository RDF

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      <http://purl.org/dc/elements/1.1/date>
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      <http://purl.org/dc/elements/1.1/description>
              " OMEN Melody Extraction<br>"^^<http://www.w3.org/2001/XMLSchema#string> ;
      <http://purl.org/dc/elements/1.1/rights>
              ""^^<http://www.w3.org/2001/XMLSchema#string> ;
      <http://www.meandre.org/ontology/components_instances>
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<http://www.imirsel.org/omen-melody-algo2/connector/4>
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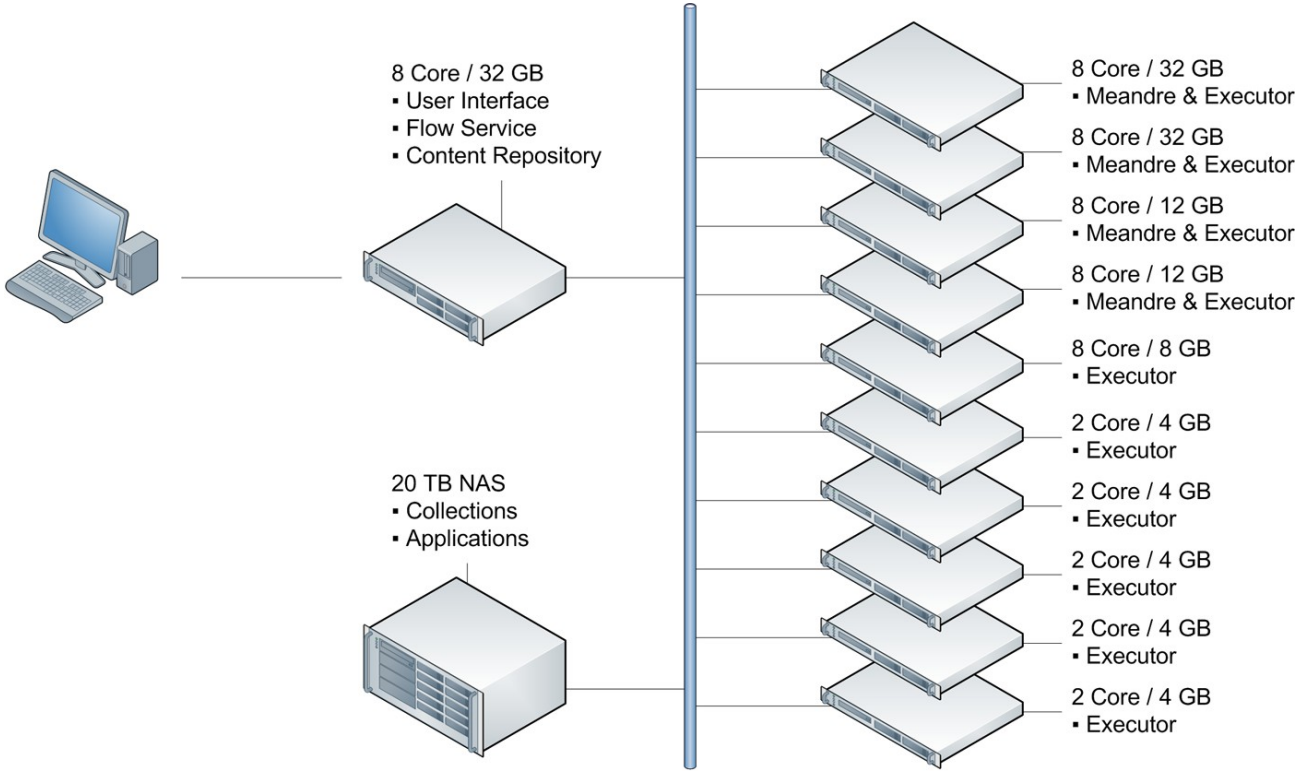
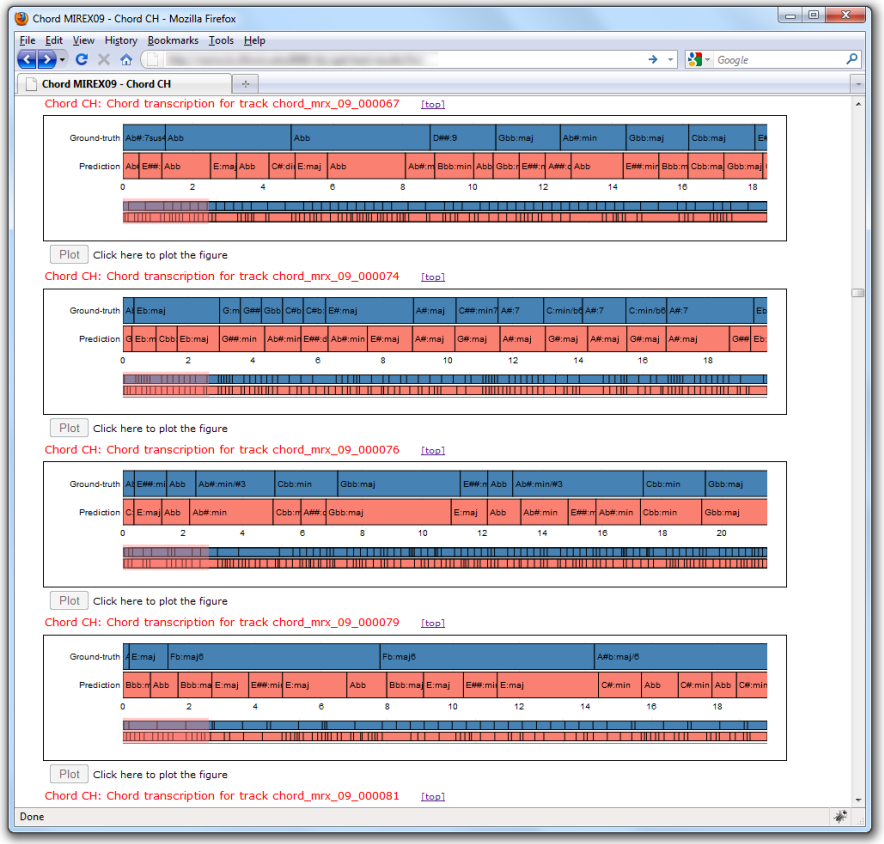
NEMA System Overview (Physical)



Job Results

- Chord transcription result plots
- Each plot represents the system's performance for a single song in the dataset
- Blue is ground truth
- Pink is the prediction
- X axis is time
- Vertical lines delineate chord instances



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