Optimization Policy Enhancement (New Constraint Editor)

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Outline

- Overview of Existing Controllers
- Vision: Integrated Rules and Optimization Policy
- Existing optimization software
- Immediate Plans for Optimization
- Optimization Policy Demonstration

RiverWare Controllers

- Simulation
- Rule-Based Simulation
- Optimization
  - Preemptive Linear Goal Programming
    - Variables
    - Linear constraints
    - Multiple linear objectives / soft constraints

Goal Programming

- Prioritized sequence of objectives and soft constraints
  - Highest priority: Move towards normal region
    - Flood control, minimum flows, etc
  - Lowest priority: In the normal region
    - E.g. Optimizing hydropower
- “Freeze” each objective.
- Use remaining solution space for other objectives.

Multipurpose Reservoir Management

- Common purposes and issues:
  - Water supply, power, flood management, environment, recreation, navigation, etc.
- Differences for Different Basins
  - Hydrology
  - Emphasis
  - History: institutions, laws, flexibility

Common Policy Needs from Common Purposes

- Get the most out of the system.
  - Both present and expected future benefits.
- Agreed upon method to balance purposes and locations.
  - Most systems: Prioritized policies that gradually reduce the solution space.
- Evolves over time
  - Flexible policy modeling.

Policies: Rules and Optimization

- Some policies have more of an optimization nature
  - Simultaneously balance the incremental benefits across time and/or locations.
- Some policies have more of a rule-oriented nature
  - Time step progression.
  - If condition A currently exists, Then take action B.

Optimization: Pros and Cons

+ Makes system and time tradeoffs easily.
+ Uses flexibility well.
+ Simultaneous solution of equations.
- Outcomes are less transparent.
- Some if-then logic is difficult.
- Some nonlinearities are difficult.
- Limited set of decision variables.

Rules: Pros and Cons

+ Fits well with a legal environment.
+ Everyone knows what the rules are.
+ Handles nonlinearities well.
- Difficult to make informed tradeoffs.
- Might be very complex to handle all of the possibilities well.
- Usually some residual institutional flexibility.

Long Term RiverWare Vision: Rules and Optimization

- Fits the broader policy need.
- Remove the existing need to choose.
  - Best of both tools.
  - Start with one and add the other.
- Shared interface.
- Shared underlying software.
- Short Term: share interface components, but separate controllers.

Optimization and Rules: mixing a little of each into the other

- Optimization with a little Rules
  - If-then logic for which constraints and objectives to solve and what to do with the results.
- Rules with a little Optimization
  - Rules functions that contain an optimization problem.
    - e.g. Optimizing over future time steps to set values in the current time step.

Rules followed by Optimization

- Rule results would be “inputs” for optimization.
- Optimize over all time periods.
- Effectively: make optimization the lowest priority rule.

Optimization followed by Rules

- Currently, we post-process optimization with simulation.
- Could post-process with rules, allowing rules to overwrite the optimization results.
- Optimization is still the lowest priority rule.

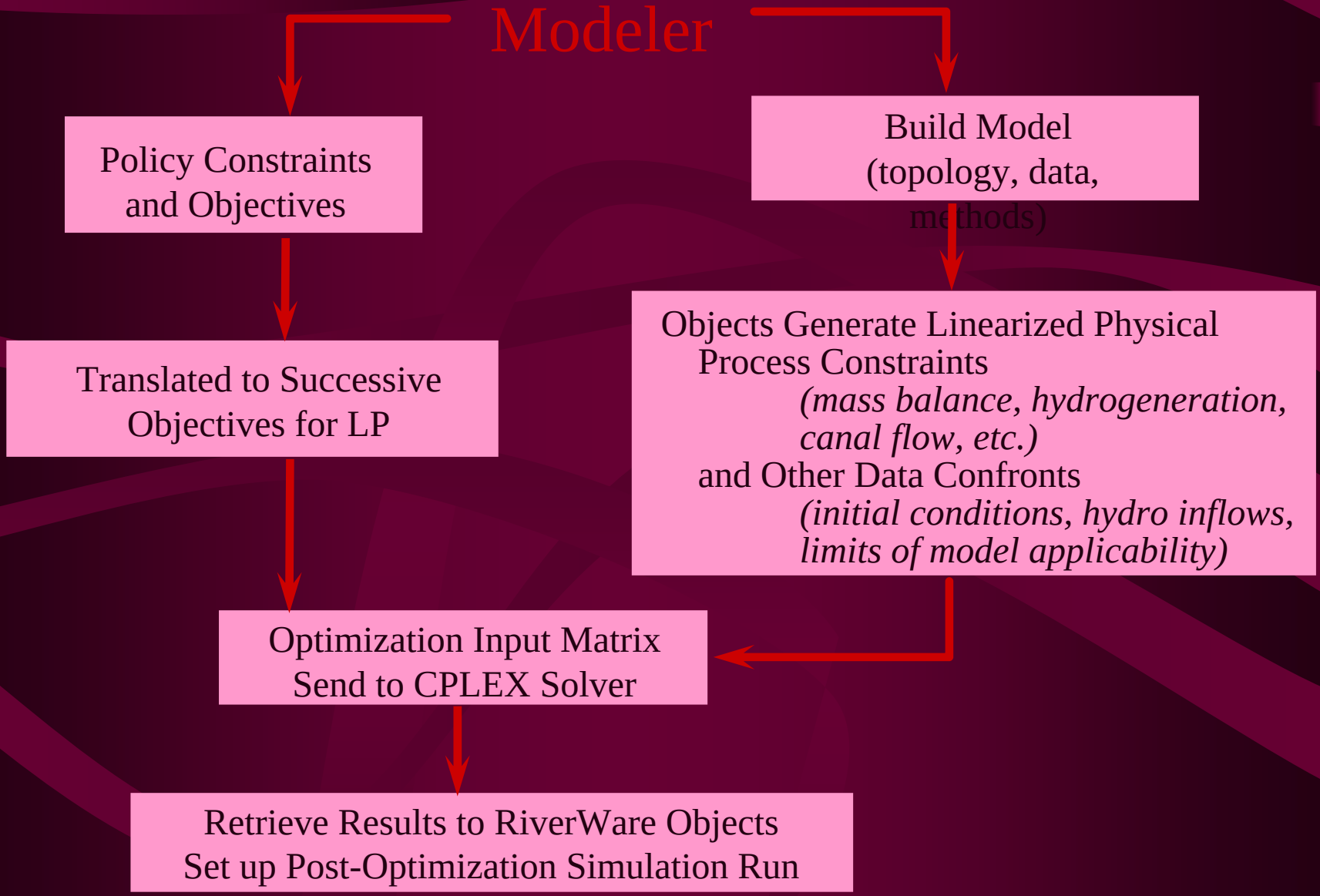
Mixed Optimization and Rules.

- Add time step control to the policy.
- Optimize in one case, fire a rule in another.
- A rule with higher priority can overwrite optimization and/or provide inputs.
- Optimization may “refire” as necessary.
- A rule with lower priority would be overwritten by a “successful” optimization.

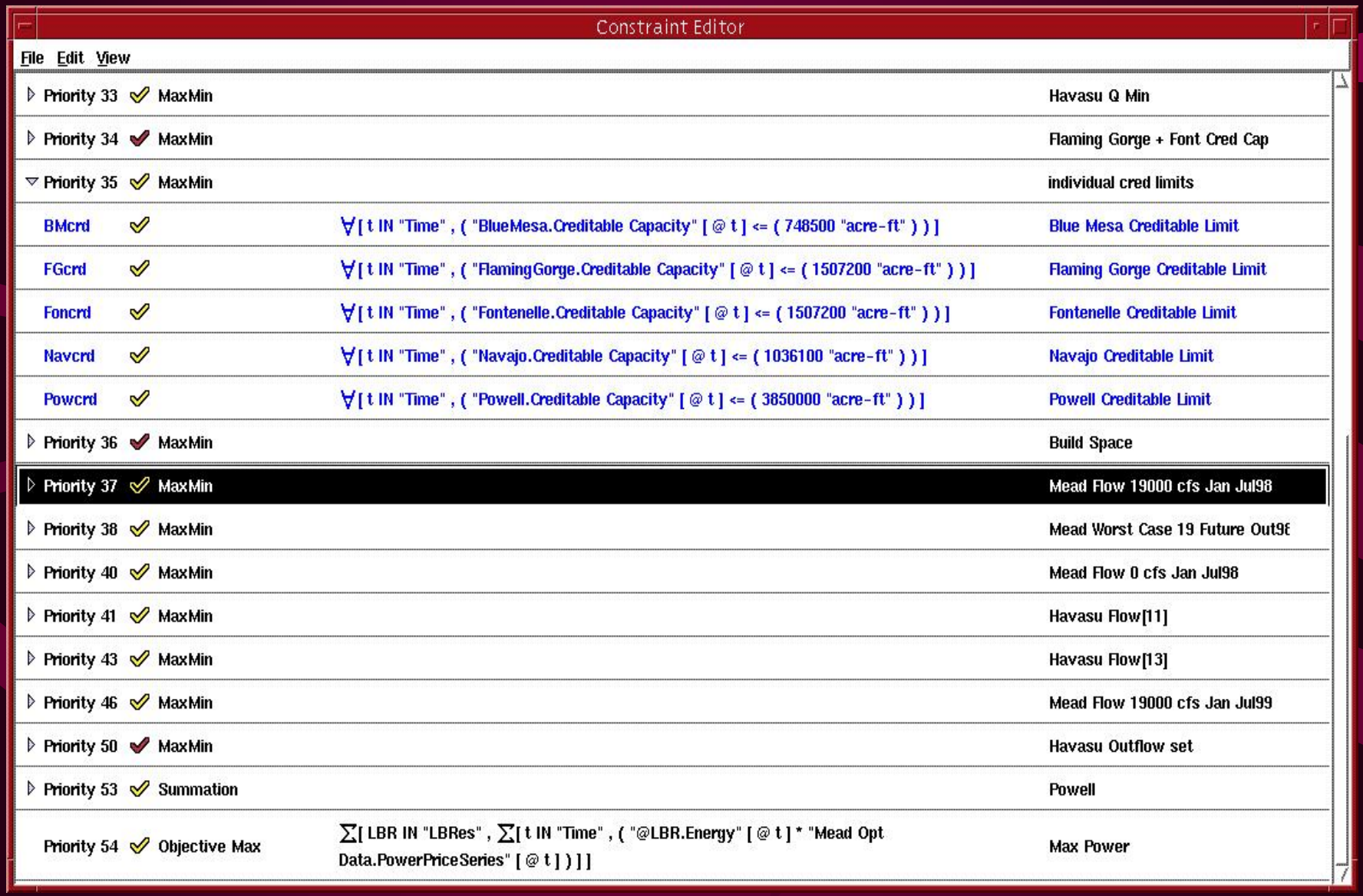
Optimization and Rules Summary

- Optimization with If-then
- Rules with Optimization Functions
- Sequential Optimization and Rules
- Mixed Optimization and Rules

Existing Generation of Optimization



Existing Optimization Policy Editor



Problems in the Existing Editor

- Create and Delete, not really “Edit”
- Easy to create meaningless expressions
- Unforgiving of mistakes
- Can’t see/change variables or physical constraints
- Requires enhancement of the underlying representation

Other Optimization Difficulties

- Users have little control over the decision variables used and the defining constraints.
- Users cannot control which parts of an optimal solution are used.
- “If-then” and “For” are very limited
- Not connected to rules
- Brittle code - Very hard to expand

Immediate Plans

- Extend rules editor to optimization
- Reproduce existing optimization capability
- If-then logic
- For loops
- Visible For-all Object list - with grey-out
- Reusable Templates
  - e.g. daily average flow
- Byproduct: Enhancements for Rules

“Physical” constraints become “Defining” constraints

- Generated only as needed to define variables that are used in policy statements.
- Visible to the end user.
- Additional variables and defining constraints may be added by the end user.

Returning Values to Workspace

- Discontinue “Opt In” and “Opt Out” columns.
- Values returned by optimization are flagged.
- Returned values are not input for a subsequent optimization run.
- Future: policy control of which values optimization returns and dispatching triggered by returned values.

Express a Wider Range of Policies

- If-then
- For
- Variables and Constraints driven by policy.
- Workspace connection

Wider Optimization Possibilities

- Prioritize constraints by a larger time step - e.g. water year
- Different Hydrologic Scenarios
- Water Rights
- Alternative Economics - e.g. agricultural
- Integer Programming
- Quadratic Programming
- Successive Linear Programming

Optimization Statements

- Objectives
  - Minimize or Maximize an expression
- Soft Constraint Set
  - Minimize deviations
- Freeze
  - Lock in the optimal value before continuing
- Hard Constraints
- Control
  - If-Then, For

Soft Constraints

- Attach deviation/satisfaction variables to each constraint
- Objective – Minimize deviations
  - Summation: minimize the sum of deviations
  - Minimax: minimize the maximum deviation
  - Repeated Minimax: “freeze” the maximum deviation and reoptimize over the remaining constraints.
  - Others are possible.