Intelligent Water Networks

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Agenda

• What is an Intelligent Network?
• Benefits of an Intelligent Network.
• Steps to create an intelligent network

• Specific Uses of Operational Modelling and Case Studies
Common Themes & Ideas

- Advanced Metering Infrastructure (AMI)
- Dissemination of data to field
- Real Time Analytics and Reporting
- Managing the Risks (of Action and Inaction)
- Event Detection “watchdog”
- Continuous Calibration of models
What is a Smart, Intelligent Water Network

A Smart Grid or network is

One that uses technology to *gather and act* on information in an *automated fashion* to improve the reliability, sustainability and efficiency of that network.
Other Smart Grids
Other Smart Grids
Other Smart Grids
Benefits of Intelligent Networks

Source: VicWater’s IWN group

- Improved Network Efficiency
  - Metering: Improved accuracy, customer sewer flows
  - Intelligent Alarms
  - Real Time Modelling
  - Operations Decision Support
  - Predicting asset failure because of hydraulic conditions
  - Prediction asset failure from field observations
  - Transient analysis
  - Leak location

- Information Management
  - Data Collection, Storage, Security
  - Telecommunication,

- Customer needs and values
  - Customer Segmentation
  - Demand Analysis & prediction
  - Water Quality
Layers of a Smart Network

1. Physical layer
2. Sensing and Control
3. Collection and Communication
4. Data Management and Display
5. Data Fusion and analysis
Charting Your Smart Water Strategy

Guiding Principles

- Ease of accessibility
- Data sharing is key
- Compliment and leverage existing IT spend (i.e. Integrate!)
- Use Off-the-Shelf solutions (configure vs. customize)
- Make hydraulic modeling a key component
- Validate SCADA and “Big Data” by using hydraulic models
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SCADAWatch™
Infinity System
IWLive™
ICMLive™
InfoWater®
InfoSWMM®
InfoWorks® WS
InfoWorks® ICM
SWMMM Live™

Real Time System Optimisation
Real Time Decision Support
Real Time Operational Modelling & Forecasting
Real Time System Optimisation
Real Time Event Detection

Innovyze®
So why operational modelling?

- Models use corporate data sources and are a great way to test assumptions (data sources) and are unbiased (they do what they are told) and are live “Operations Manuals”

- Creation of a model is audit of GIS/AMS
- Calibration of a model is audit of SCADA
- Operational modelling is audit of your Ops Manuals

The most that can be expected from any model is that it can supply a useful approximation to reality:
All models are wrong; some models are useful

George Box - Statistics for Experimenters
Specific Uses of Operational Modelling

Assess the system under abnormal events

• Examples:
  • Isolation (burst and repair)
  • Pump Station failure/shutdown
  • Isolating key assets (treatment plant or reservoir)
  • Changes to supply (using a different water source)

• Predictions must be quick and accurate
• Assumptions need to be current and relevant
• Potentially identify the “abnormal event” before the customer notices
Pipe Burst Example

• The operator can use IWLive to add extra demand to the system to simulate a burst in the network.
• They can isolate the pipe to be repaired and see the effect on the network
• They can add in additional water (tanker supplies) to see if this method will help.
Simulation results showing flow reversals and poor pressure away from burst area.
Isolate main to repair burst
Start of burst, pipe not isolated

<table>
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<th>Object ID</th>
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<th>Time of 1st Warning</th>
<th>Time of 1st Worst Warning</th>
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</table>
Pipe Isolated
Pipe Isolated, start of morning peak, new low pressure area to the north east.
Pipe Isolated, morning peak demand time.
Pipe isolated, morning peak demand over, pressures return to acceptable levels.
Specific Uses of Operational Modelling

Train and support Operators

- Examples:
  - New employees don’t have 30 years to “learn the system”
  - Ops Manuals/GIS aren’t always current
  - Test strategies for changes to system
  - Individual risk appetite
  - Understand the whole network, not just “their patch”

- Operators must have confidence in predictions
- Operators must be able to use the interface
- Understand and challenge assumptions
- Outcome is improved model
- Repeatable decision making
A real story …

• Authority needed to shut down on a critical main to replace a valve
• Operators said “no way”, “never work”, “can’t be done”, “44,000 customers will be without water”
• Calibrated model showed it should work
• Ops said “don’t believe it”
• Model was compared to 3 months of SCADA and field data
• Ops said “still don’t believe it”
• A field trial was held – close the valve and monitor the system but first predict what will happen
• Observed and Predicted pressures varied by less than 5m.
• Supply was not compromised
• The valve replacement was completed with no detrimental customer impacts
• Increased operator confidence in the model (for that part of the network)
One forecast
Ormany “Normal” demand
25% additional demand
Compare the scenarios

Graphs showing data comparison.

Table: Demand (l/s)

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<tr>
<th></th>
<th>Max</th>
<th>Min</th>
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<tbody>
<tr>
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<td>0.001</td>
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</table>

Table: Pressure (m)

<table>
<thead>
<tr>
<th></th>
<th>Max</th>
<th>Min</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>22.104</td>
<td>16.558</td>
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Selection List: Custom Selection
Specific Uses of Operational Modelling

Real time understanding of Water Quality

- Examples:
  - Biological or chemical contamination at the source – where do we flush/notify customers?
  - If a customer has complained at this address – where else could it be?
  - Optimising water turnover in tanks
  - Preventing sewer spills

- Once hydraulics are right then this should be easy
- Need sensors in network to calibrate the “easy” parameters
- Identify critical locations for different contaminants
Real Time Water Quality Analysis

- Water age or contaminant modelling
- Create water quality incident and response runs
- Long projection runs
- Example applications:
  - Water age – how to flush old water
  - Chlorine – dosing optimisation
Specific Uses of Operational Modelling

Analyse reaction to past events

• Examples:
  • Post incident review
  • Understand the decision making process “why did we ...”
  • Use hindsight to see if there was a better solution “instead could we have ...”
  • Test other options “what would have happened if ...”

• Training of operators
• Understand the network limitations and flexibility
• Document strategies for future problems
• Identify future “alarm bells” how did we know there was a problem?
Folsom Street Main Break

- April 25th at 3:30 a.m.
- 16 inch (~400mm) distribution line
- Caused 5 x 10 meter sinkhole
- 2nd break at that location within the last year
- Street closed four days
April 25 Pipe Break - Tank Response

Break Location

Closest Tank in Same Zone
April 25 Pipe Break - Tank Response

IWLive Alert Time

SCADA Alarm Time
April 25 Pipe Break - Tank Response

IWLive Alert Time

SCADA Alarm Time
Tank Levels with Break Modeled

GUNBARREL (Tank)

Level (ft)
0:00 06:00 12:00 18:00 00:00
Level  Live Data  Green

BOOTON (Tank)

Level (ft)
0:00 06:00 12:00 18:00 00:00
Level  Live Data  Green
Tank Levels with Break Modeled
Pressure Logger vs. SCADA ~110psi (~80m) variance

Yellow is unusually high pressure

What else was noted?
These Red Pipes are Really Closed
This Red Pipe Really Supplies This Area
Results After Reconfiguration
Specific Uses of Operational Modelling

Proactive operation of system

• Examples:
  • Increased efficiency – less energy, chemical costs
  • Applies to sewer networks also
  • Reduce pressure without compromising supply (fire fighting)

• Dynamically change the system to optimise
• Understand the network limitations and flexibility
Boulder Forensic Analysis
IWLive Benefits

- Engineer used to spend ~3 days setting up model to mimic conditions during major events
  - Various analyses performed
  - Field crew, engineers, and operators meet when finished to discuss options

- Model performing better after each IWLive analysis for true operational performance
  - Roughness, closed pipes
  - Pressure zone delineation

- Eliminates need for new calibration

- Enhances forecasting accuracy
Real Time Verification Example

Model tracks well for first 11 hours

Then PRV stays open longer than the model predicts

Then pump kicks on and tank fills higher than the model predicts

And the tank drains to a lower level in reality than the model predicts
A Case Study: Sewer pump optimisation in Japan

• Use ICMLive to predict sewer flows
• Pumps can be gradually ramped up to optimum operating point
  • Pumps can be run longer at lower speeds
  • More efficient pump costs
  • Reduced wear and tear on pump
• Pre-emptively draws down system before peak
  • Flatter flows at outlet
  • Increased storage in system for peak
Intelligent Water Networks are being driven by:

- Aging operations workforce = loss of knowledge
- Aging and growing population = less money but larger networks
- Systems being “worked harder” = less inbuilt safety factors
- Energy Costs increasing = efficiency improvements
- Customer Satisfaction = Water has to be good quality, cheap, reliable etc. etc.

What is changing to support IWN?

- Hydraulic Models have improved enormously (speed and complexity)
- Increased SCADA reliability
- Smart devices = increased flexibility and knowledge sharing
- Cheaper Telemetry Costs = Automated Meters = The Internet of Things
Extended functionality

- Continuous monitoring
- Automatic prediction
- Forecast demand
- Evaluation of solutions (real or anticipated problems)
- Planning and training in the control room
- Optimisation of financial (and carbon) costs of supply or intervention
IWLive Workflow - Example

Projection
Real time modeling
 Runs every 30 min

Incident
Past, present, or future
Real or fiction (What-if’s)

Pipe burst

Response
User tests how system will respond

Close valve set A

Close valve set B

Turn on standby pumps

Change PRV setting

Compare
User decides which option to execute

$, good pressures

$$$, low pressures

$$, worse WQ

$, best WQ

Current 24-hr projection

Valve out for maintenance
How does IWLive Work?

• Baseline models
• Schedule of runs (update baseline)
• Automatic model update from live data
  • reservoir levels
  • pump status
  • valve status
• Calendar and weather feeds
• Project demand in order to assess potential problems.
What results are available?

• Simulations run automatically
• Results are processed automatically
• Warnings are displayed on the control room map
• A highlighted polygon on the map indicates a prediction of problems in the next few hours
• Grid displays the time of onset of these problems.
What then?

- Operator can change the status of valves and pumps
- Manually re-run simulations in order to evaluate possible solutions to the problem.
Users

- SA Water
- Yarra Valley Water
- South East Water
- Current trials in Brisbane, Sydney and Melbourne
- City of Boulder, Colorado
- Colorado Springs Utilities, Colorado
- City of Guelph, Ontario
- Detroit Water and Sewer Dept, Michigan
Thank you

Questions?