Smart and Intelligent Water Supply Systems

Current practices in the US

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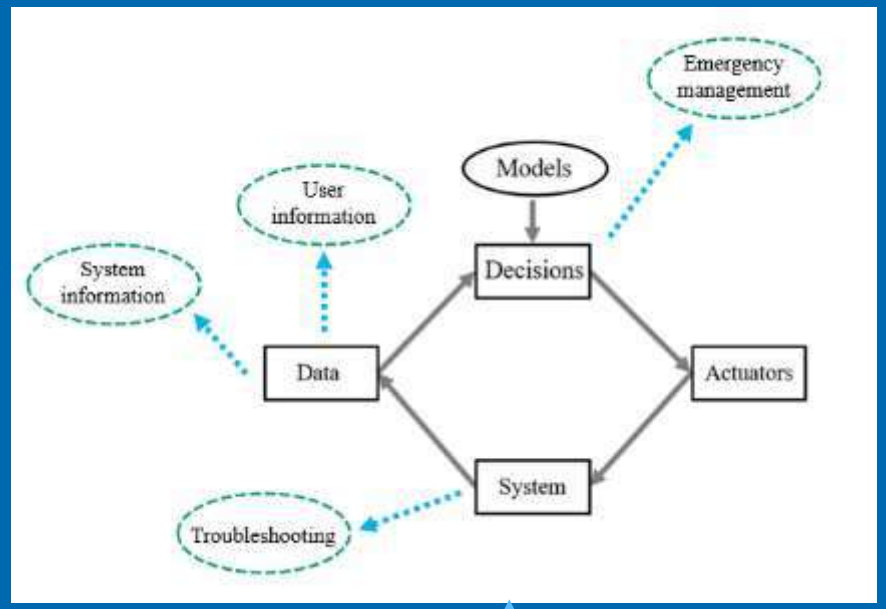
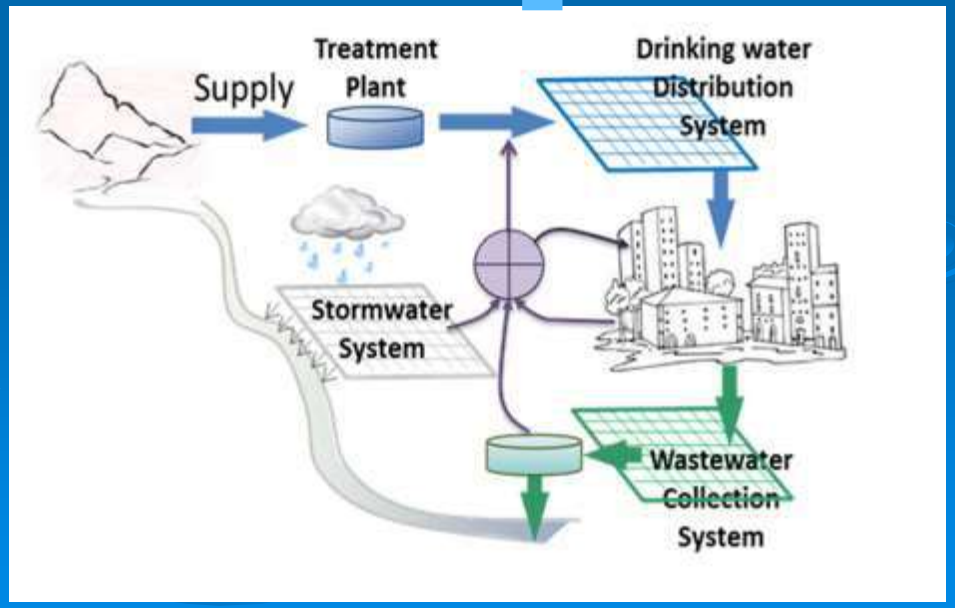
What are smart and intelligent water systems?

- No consensus definitions
- Evolving concepts
- Evolve with IT and useful devices
- Parents = automation and control engineering

Smart water city model

https://www.softwebsolutions.com/resources/IoT-enabled-water-management.html





Context of US water utilities

- Distribution systems direct link to customers
- Different than source and treatment
- 50,000 mostly-small utilities
- Management from passive to advanced
- Gap: Some utilities innovate, many struggle
- Many evolving products
- Finance is a continuing issue

Challenges of distribution system management

- Dispersed layouts with myriad aging components, some inoperable
- Buried pipelines with difficult condition assessment
- High expense, disruption of repairs
- Measuring water quality and pressure required at many locations
- Operational issues with hydraulics, water quality, system integrity
- Breaks and compromised water quality, leaks hard to find
- Organizational management responsibilities not centralized
- Multiple access points, including hydrants, intrusions, security issues

Chronology of distribution system research

- Water industry research built up slowly
- Before Safe Drinking Water Act, little distribution system research
- 1980s projects on issues like main breaks and network models
- Studies about lead release initiated by USEPA during the 1980s
- In 1990s, information about condition of distribution systems
- WRF now lists over 140 project reports on asset management
- Research on network models led to EPAnet as main model engine

How innovations occur

- Innovative utilities, vendors, regulators, and consultants
- Water supply, wastewater, and stormwater are different
- In water supply, emphasis on distribution systems
- Distribution system optimization (DSO) evolving
- Developing technologies:
  - Advanced metering infrastructure (AMI)
  - Automatic meter reading (AMR)
  - Water loss control
  - Hydraulic and water quality modeling
  - Digital twins

Survey of utilities about innovations

Topic selection from industry reports and experience with WRF

Infrastructure management

- Asset management (including condition assessment)
- Prioritization method to select pipes for renewal
- Pipe break simulation model

Operations management

- Intelligent water systems (smart or digital)
- Distribution system optimization
- Water auditing with IWA/AWWA method
- Hydraulic and water quality model (includes concept of digital twins)

Survey

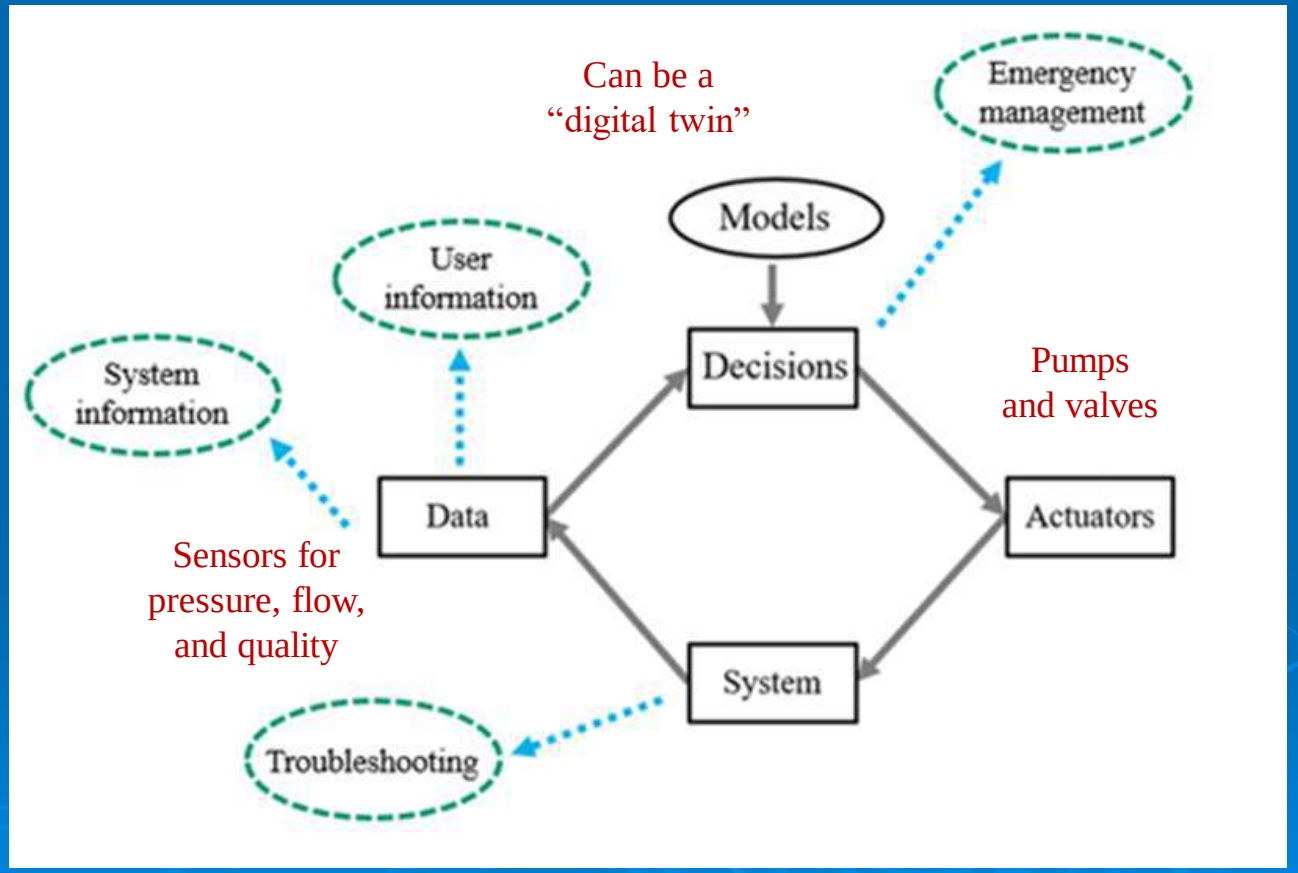
- Sent to individual utilities and AWWA sections
- Distribution system managers are busy and hard to reach
- A few are technological gate keepers and interested in research
- As of March 10, 2023, some 23 responses were received
- Distributed by size and region
- Plans are to continue the survey

Asset management

- Evolved as shared experience among sectors
- Technology and pressures grew, and vendors developed products
- Involves tools for maintenance, risk assessment, and planning
- Glue provided by information technology and data management
- AWWA survey showed mixed commitments to asset management
- Linear assets condition assessment vary widely
- Only a few states require AM, and in conjunction with DWSRF program
- 20 of 23 surveyed utilities have formal asset management systems
- Around half use commercial software packages
- Ways to organize the systems vary

Intelligent systems

- No standard framework of its elements
- Information for users and management
- AMI, AMR, automatic controls
- Awareness of applications seems low
- SCADA evolving for a long time
- Pressure management benefits
- Only few utilities report using AMI
- Data quality, cost, maintenance concerns



AMR vs. AMI: What's the Difference?

Automated meter reading = communication technology water utilities use to automatically collect water consumption and status data from water meters.

AMR either walk-by or drive-by. An endpoint is connected to the meter's encoder register. The endpoint captures water flow and alarm data with a data receiver in proximity to the device.

Meter data transferred to database where utilities monitor usage, troubleshoot issues and bill customers.

Advanced metering infrastructure = integrated system of water meters, communication networks and data management systems. AMI doesn't require personnel to collect data, but system transmits data to utility at predetermined intervals via a fixed network. The utility can monitor water usage and system efficiency, detect malfunctions and recognize irregularities.

(From Badger Meter)

https://www.badgermeter.com/blog/amr-vs-ami-whats-the-difference/

NRW=non-revenue water, or water that is not metered through customer meters so charges can be paid.

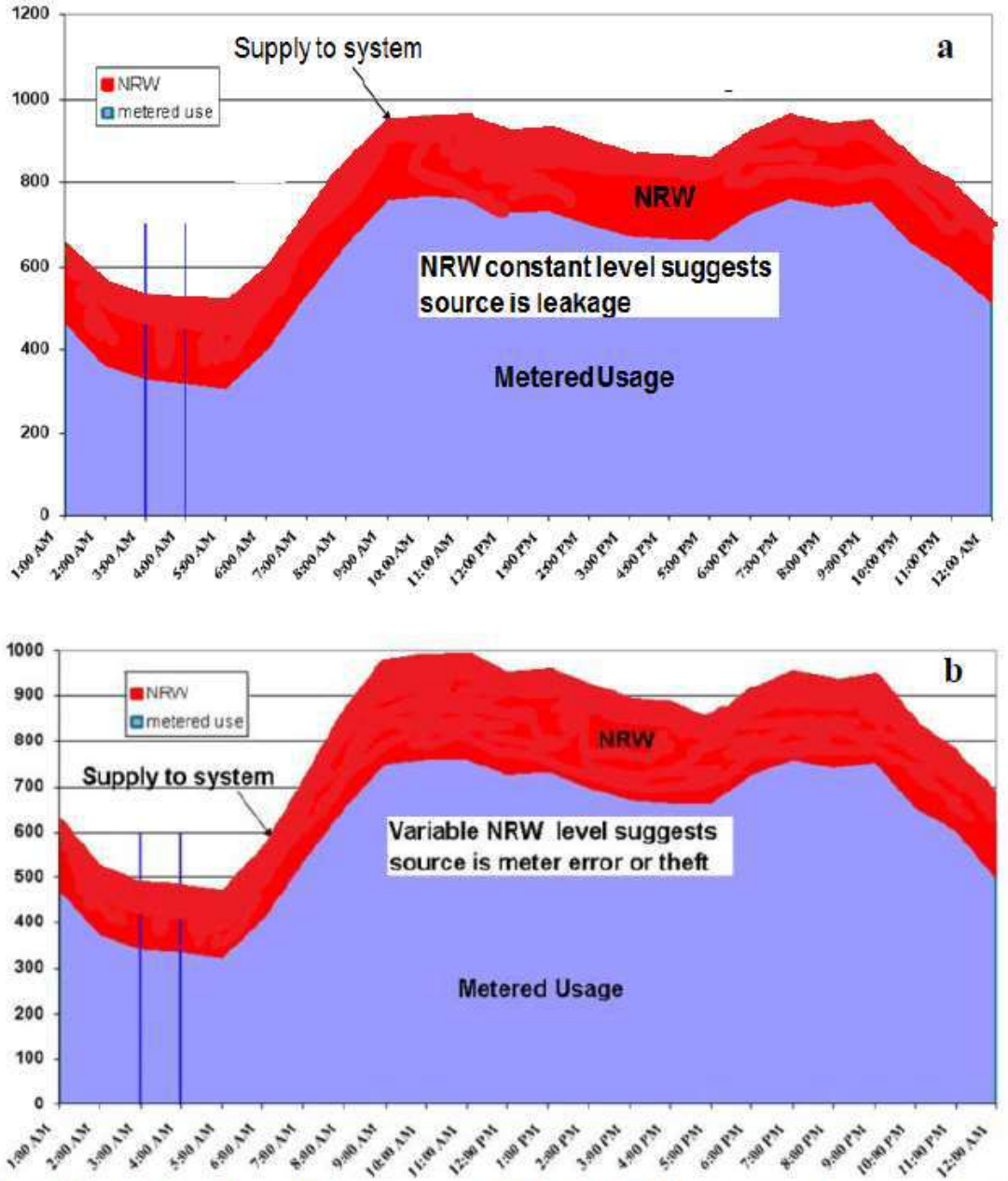


Figure 2.2 Diurnal pattern showing system with input flow and aggregate customers use a) suggesting leakage and b) suggesting customer related water loss

Distribution system optimization

- Different understanding of optimization: mathematical optimization and process optimization
- Distribution system and treatment plant use process optimization (achieve goals without violating constraints)
- WRF project developed an approach to support Partnership for Safe Water
- Survey showed little consensus about DSO
- Three utilities reported participation in PSW

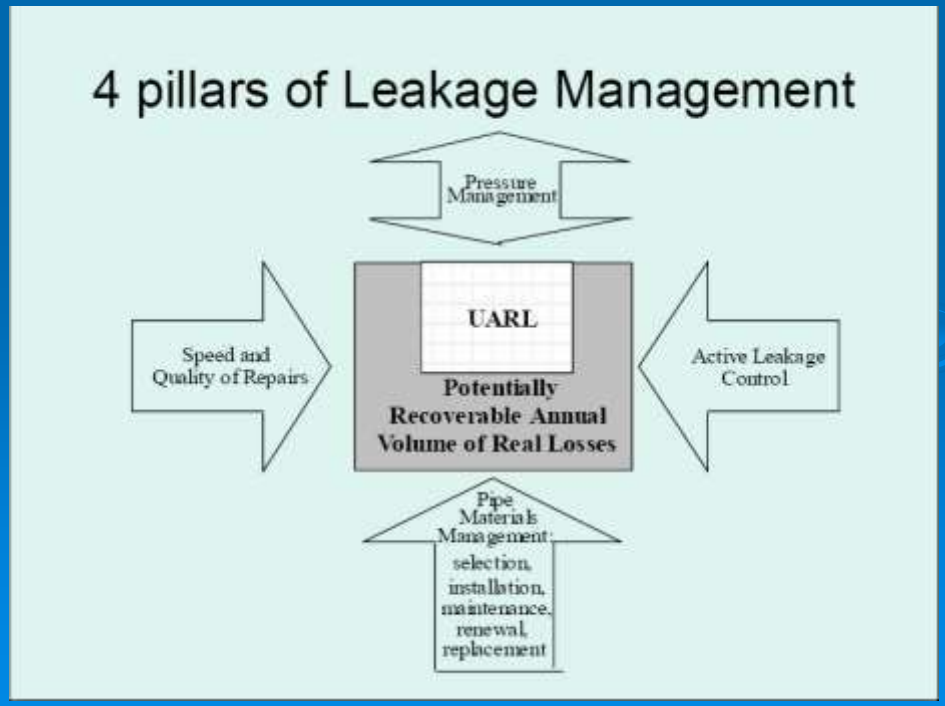
The three top optimization topic candidates were as follows:

- Chlorine residual representing Water Quality Integrity
- Pressure management representing Hydraulic Integrity
- Main breaks representing Infrastructure Integrity

Water loss control

- Global problem
- Not unusual to have ~50% of water lost
- Lost water means low pressure
- Low pressure admits contaminants
- Lost water = urgent problem for safe water

- Almost all surveyed utilities perform water loss auditing using the IWA/AWWA method



Prioritization

- Prioritization can utilize data-centered information for risk-based decisions
- WRF categorized methods at voting, ranking, and systems analysis levels
- With systems analysis, multiple data can be used, such as break simulation models
- No studies to assess implementation of methods have been identified
- Survey results showed mixed approaches
- Most utilities lack formal methods other than capital improvement programs
- Some utilities have formal methods, but most do not use models or analytical procedures.

Pipe break simulation models

- Pipe break simulation models use statistics and forecasting to project remaining life of pipe segments
- Only two utilities reported using a pipe break simulation model

Hydraulic and water quality modeling

- Essentially 100% of the utilities use a hydraulic model to support operations and decisions
- Some outsource their operation to consultants
- Applications range across different purposes like fire flow, water age, system planning, capacity assessments, tracking assets, and studying problems like low and high-pressure areas.

Unusual issues reported

- Large and dispersed geographic layout, pressure problems.
- Lack of money and staff
- Downtown concentration, built-up area
- Shrinking city
- Missing valves
- Weather, soil conditions, corrosion, failure of DIP
- Different source waters
- Low water use during winter
- Iron/manganese problems
- Merger of systems and blending of sources
- Irrigation in utility service area
- Lead service line issues
- Difficulty to coordinate with road construction

Conclusions

- IWS are grafting new technologies onto old systems
- Leading utilities are pioneering experimentation with IWS
- Small utilities face management capacity challenges
- Vendors are creative with new products/software
- AMR and AMI are leading products
- Research probes possibilities , subject to reality checks
- Models and water loss control are widely implemented
- Uses of asset management and prioritization are variable
- DSO with performance checking not off the ground yet

Thank you!

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