BUILDING A WORLD OF DIFFERENCE

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INTEGRATION OF NOVEL SENSOR SYSTEMS AND DECISION TOOLS FOR DIRECT POTABLE REUSE 14-01

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WHAT IS THE ISSUE?

- **There is a wide variety of potential contaminants**
  - Pathogens
  - Trace organics
  - Compounds of emerging concern
  - Unknown
- **Can we monitor for these contaminants?**
  - Some real-time
  - Most require off-line analytical analysis
  - Takes time

Is the water safe to deliver? When should I act?

PROJECT OBJECTIVES

- **Develop an operational Decision Support Tool (DST)**
  - Use diverse number of sensors
  - Identify high priority alerts – variations/breakthrough
- **Integrate existing sensors into a network that can act as an early warning system**
  - Multiple data sets - SCADA, CMMS, others
- **Build on previous WRRF projects that defined Critical Control Points (CCP) within a DPR treatment process**
- **Develop a framework for sensor data integration**

Key aspect – "Real-time"

WHAT IS THE CONCEPT TO PROVE?

- **There are real-time water quality analyzers that we can use to verify performance**
  - Direct measurement
  - Surrogate analysis
  - Role of QA/QC in monitoring
- **Can we take a "wide" view of data and verify performance from different types of data**
  - Real-time WQ sensors
  - Off-line WQ analysis
  - Operational data
  - Maintenance data

WE LIVE IN A WORD WHERE……

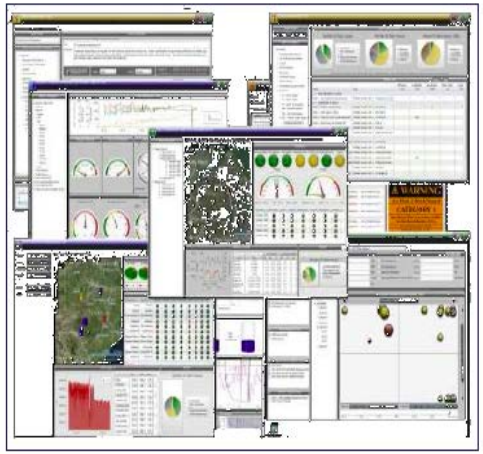
- **Over 100 Billion credit card transaction in 2015 (source creditcards.com)**
  - Use machine learning and data mining
- **20+ Emotion Recognition applications**
  - Joy, Sadness, Anger, Fear, Surprise, Contempt, and Disgust
  - Used for national security
- **“The Day a Computer Writes a Novel”**
  - Artificial intelligence “written” short story
  - Passed first round of competition (source Futurism.com)

WE WORK IN AN INDUSTRY THAT……

- **Has prevalent data silos**
  - How many people do you have to talk to?
  - Thousands of points go unused but are saved
- **Lives in a spreadsheet world**
  - Uncontrolled copies
  - Manual updating for “current” answer
- **Our idea of monitoring is**
  - High/High-High alarm
  - Low/Low-Low alarm

Data

Data Analytics = Value



Black & Veatch **ASSET360 Platform**

Cost ↘

Size ↘

Availability ↗

Function ↗

Cost of Storage ↘

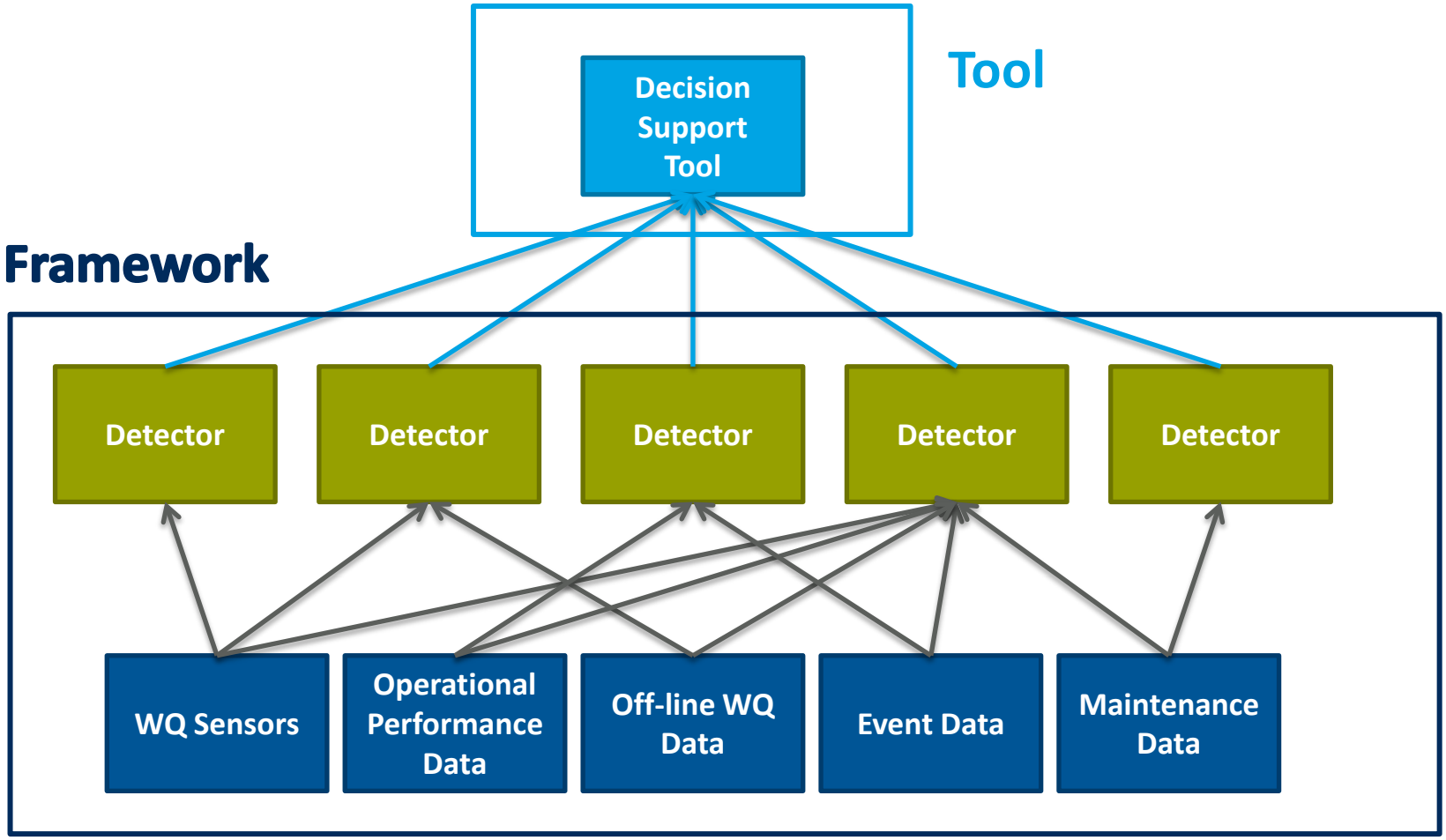
Cost of Sensors ↘

Computing Power ↗

Access ↗

Technology will transform how to make better informed operational decisions

WATER QUALITY EVENT DETECTION

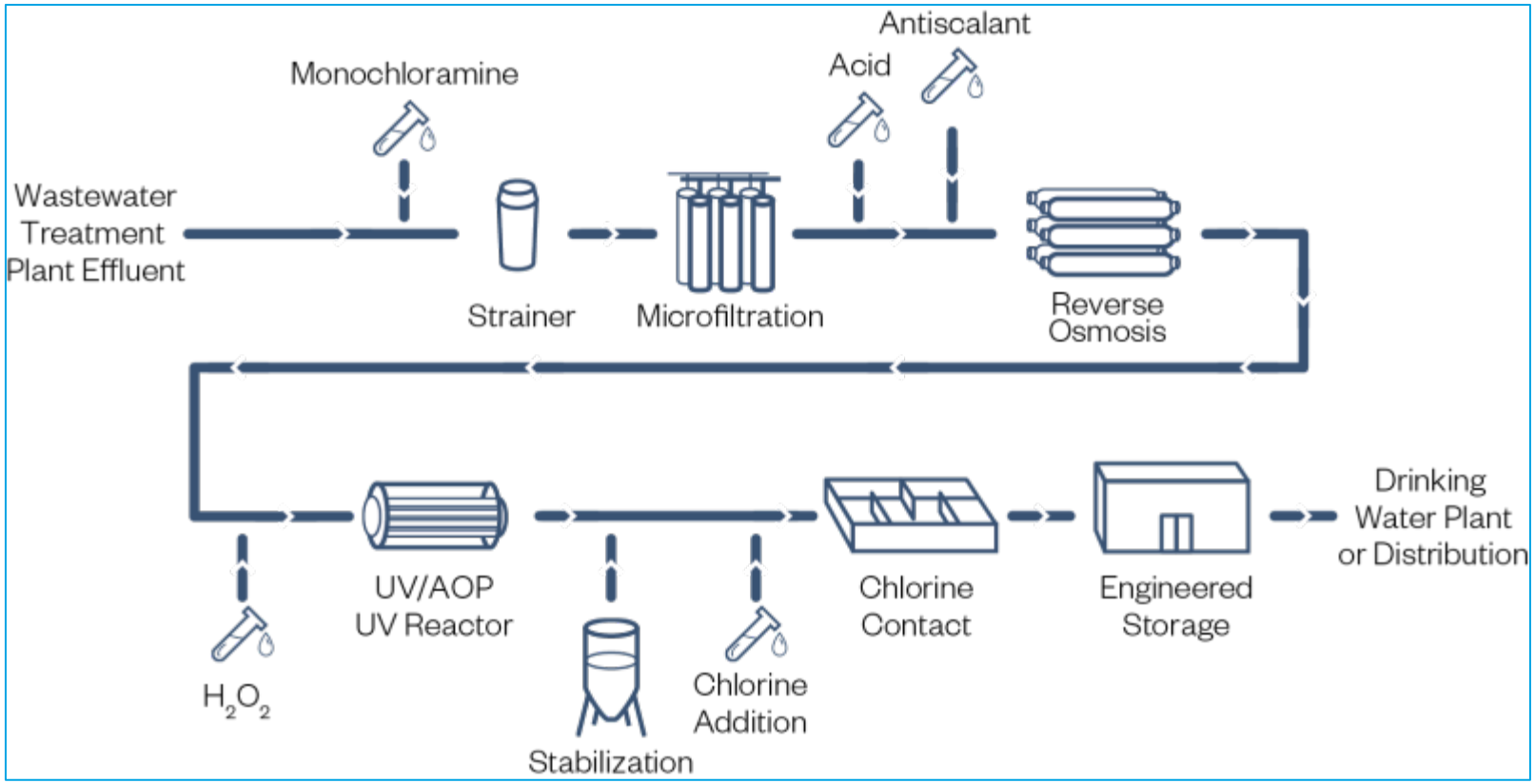


Focus on "wide" definition of sensor and data

TYPES OF MATH TO DETECT ANOMALIES

Math algorithms Category	Description / function	Common Algorithms
Classification	Classifies data into different categories	Support vector machine; Boosted and bagged decision trees; K-nearest neighbor; Naïve Bayes; Discriminant analysis; Logistic regression; Neural networks; Perceptron
Regression	Predicts continuous data	Linear model; nonlinear model; regularization; stepwise regression; Backpropagation; gradient descent
Clustering	Finds natural groupings and patterns in data	k-means and k-medoids; Principal component analysis; support vector machine; hierarchical clustering; Gaussian mixture models; hidden Markv models; self-organizing maps; fuzzy c means clustering and subtractive clustering .
Trigger	Derives execution from starting set of data and rules	If/then statements; greater than/less than

EXAMPLE REUSE TREATMENT TRAIN



Reference:
WRRF 13-03 Critical Control Point assessment to quantify robustness and reliability of multiple treatment barriers of DPR Scheme.

EXAMPLE CRITICAL CONTROL POINTS & CRITICAL OPERATING POINTS

Process or Ancillary Equipment	CCP /COP	Example Monitoring Parameters	Example Analyzer/Process Control	Controlled Health Effects	Process Effect
Chloramine Dosing System	CCP/COP	Total Chlorine	Chlorine, ammonia	Reduces DBP formation	Membrane Biofouling Control; prevents chlorine damage to RO
Antiscalant dosing system	COP	Chemical Dose rate	Pump signal transmitter, level sensors	----------	Reduces RO scaling/fouling
RO	CCP/COP	Electrical conductivity /TOC	Online EC/TOC analyzers	Removes inorganics, organics, trace organics, etc	Increase UVT of UV/AOP feed water

References:
WRRF 14-01/WRRF 13-03 / WRRF 09-03

MONITORING CLASSIFICATIONS FRAMEWORK

- **Regulatory/Critical**
  - Critical Parameter/Critical Limits/Critical Alert Limits
- **Operational Integrity**
- **Operational Performance**
- **Water Quality**
- **Events**
- **Maintenance**

EXAMPLE FROM MF/UF SYSTEM

Monitoring Classification	Monitoring Scenarios	Type of Math Algorithm	Water Quality - Online	Operational Data	Event	"Yellow"	"Red"
Regulatory/ Critical	Total chlorine (CP)	Trigger	total chlorine, free ammonia			less than target	less than cricial level
	Pressure decay test (CP)	Trigger		pressure decay test result		less than target	less than critical
Operational Integrity	Rate of pressure decay	clustering		pressure decay test result, pressure decay history, starting pressure, ending pressure, test time	date of membrane repair	greater than target	

DETECTOR ROLE-UP DASHBOARD CONCEPT

Overall could be "weighted" total risk

TASK 4 - DECISION SUPPORT TOOL (DST)

- **Develop DST**
  - Requirements
  - Programming, Interface
- **Develop Operations Response Procedures**
- **Develop Protocol for Pilot and Demonstration-scale Testing**
- **Pilot-scale Testing of DST**
  - WEST Center
  - Utility Site
- **Final DST**

FINAL THOUGHTS

I HAVE SOME QUESTIONS

- **Did these concepts change your perception?**
- **Will we ever be able to directly "sensor" for DPR?**
- **What other "data" would you monitor to verify performance?**
- **Should the "response system" be decision support or actually control?**
  - What would the public's expectation?

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Together

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