Development and Application in Water Distribution Networks of Smart Water in China

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Xi'an, China
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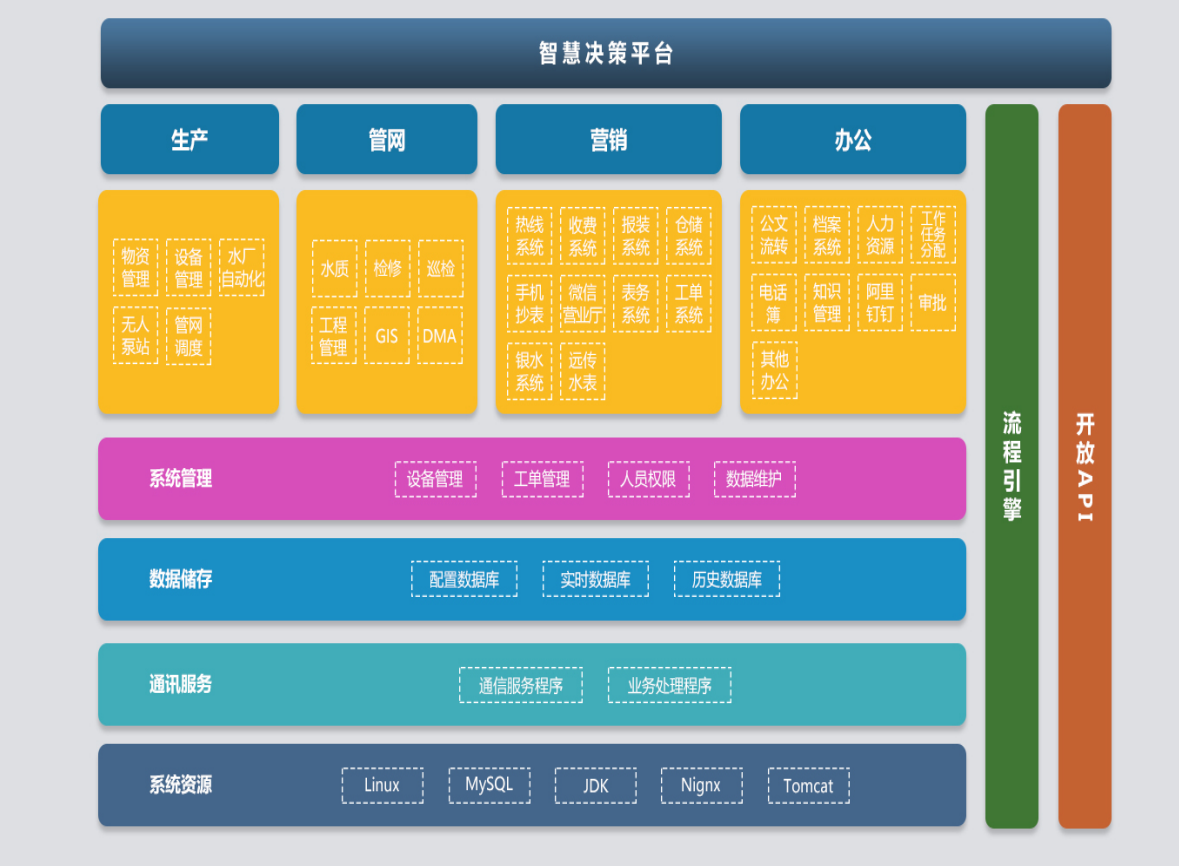
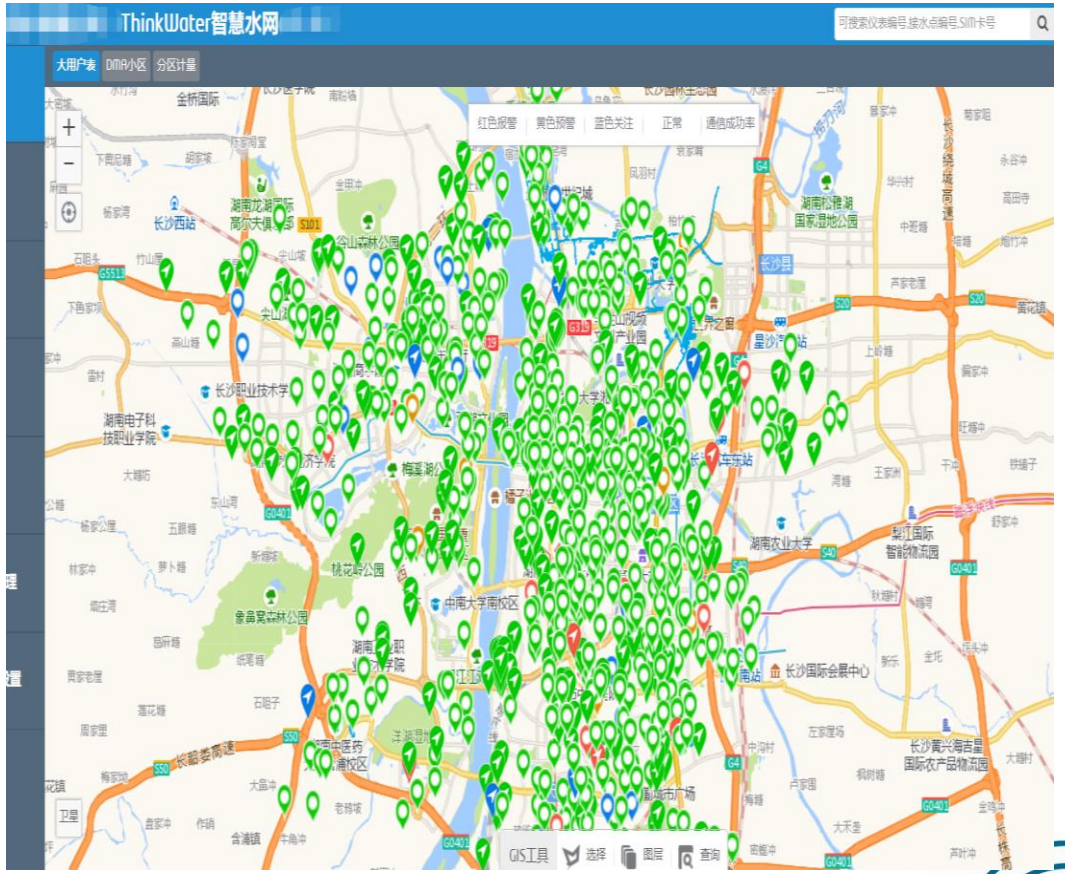
Outline

1. Background
2. Application
3. Research group

1. Background

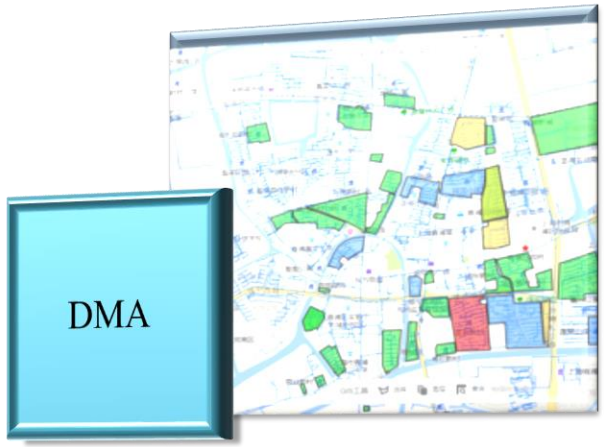
SmartWater®functional framework

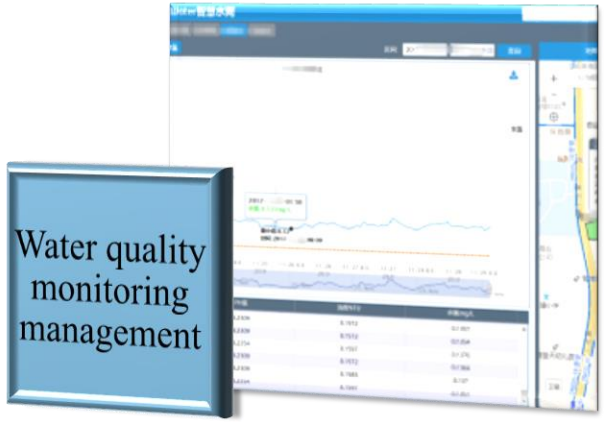


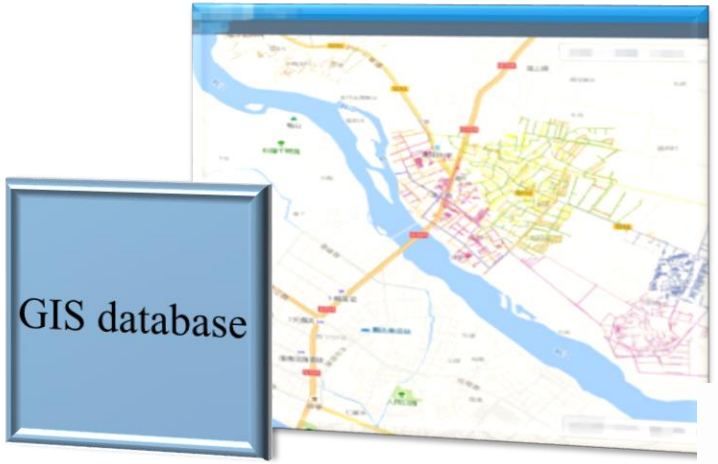


1. Background

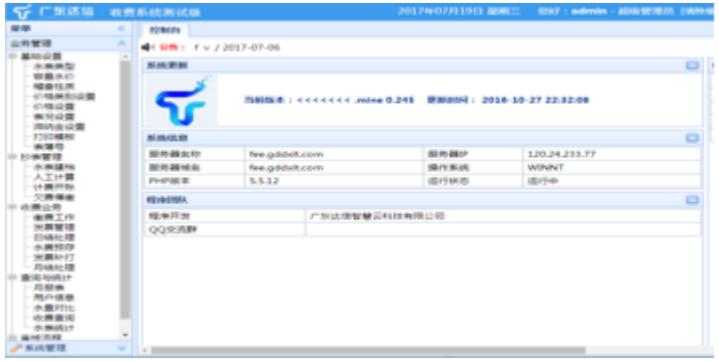
Data collection platform



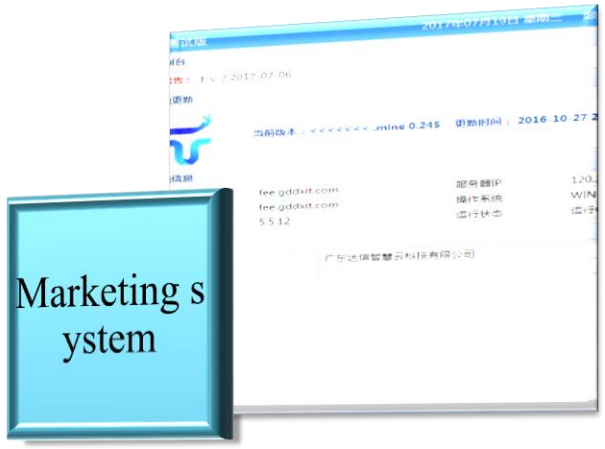


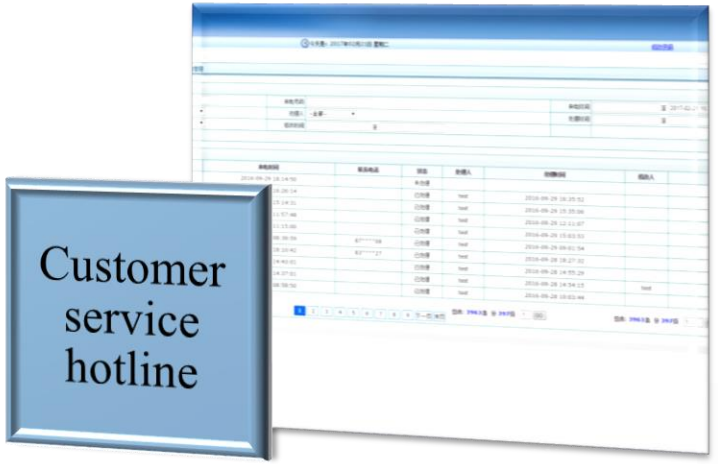


1. Background



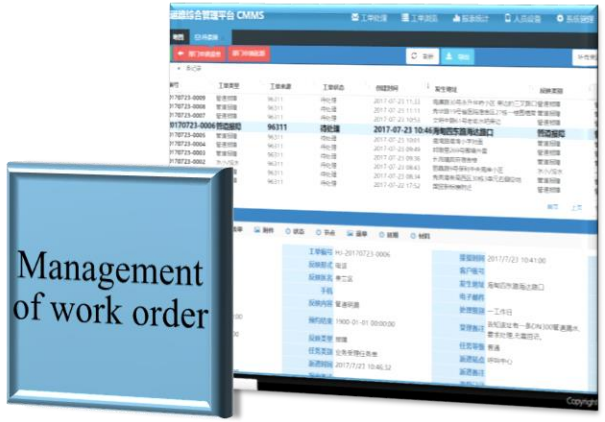
Sale management terrace

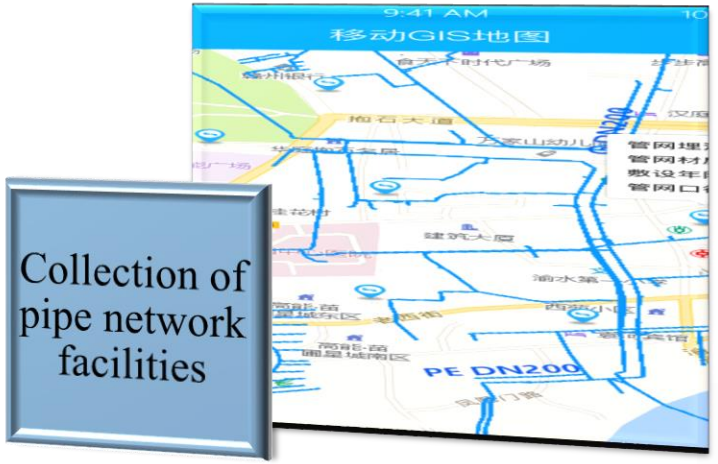




1. Background

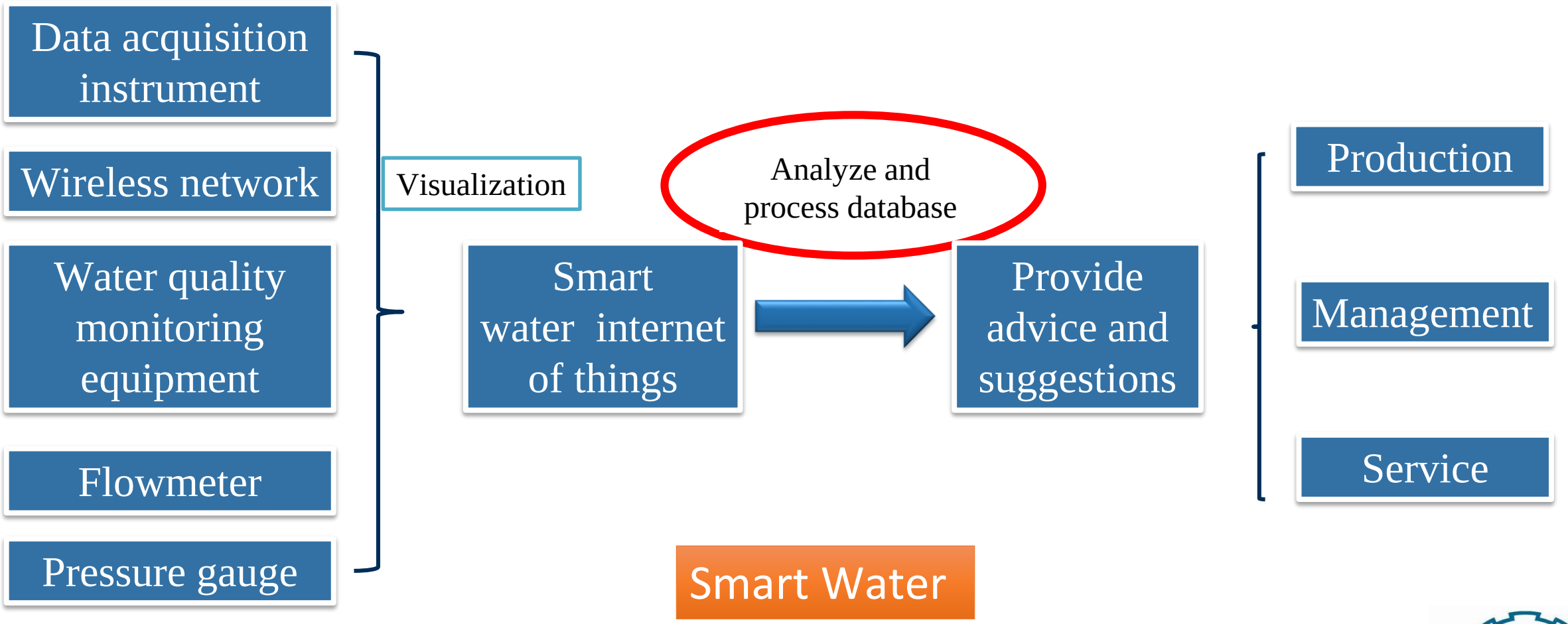
Operation platform





1. Background

1.1 The definition of smart water



1. Background

1.2 The necessity and feasibility of smart water in China

1. The total water supply of China is the largest in the world.

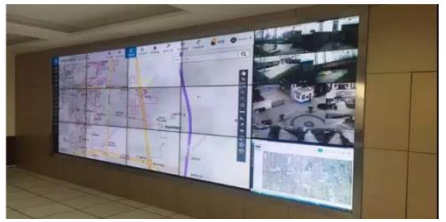
2. For the need of the development of water supply enterprises.

3. The investment of informatization construction project is large

4. National policy supports the development of smart water.

效果评估

实施主动漏控管理前，该片区产销差水平约为50%左右。通过大用户旧表改造更换安信电磁水表和ThinkWater®漏控系统助力小区DMAs的持续建设两大关键举措后，示范区以每年降低10%的速度产销差持续下降。到2016年底，示范区产销差已由建设初期的50%多下降到30%左右，成效非常显著。



1. Background

1.3 The development of smart water

At present, most cities are located between these two stages in China .

Initial stage

Enhance water supply capacity

Automation stage

Automatic control of valves, pumping stations and production processes.

Digital stage

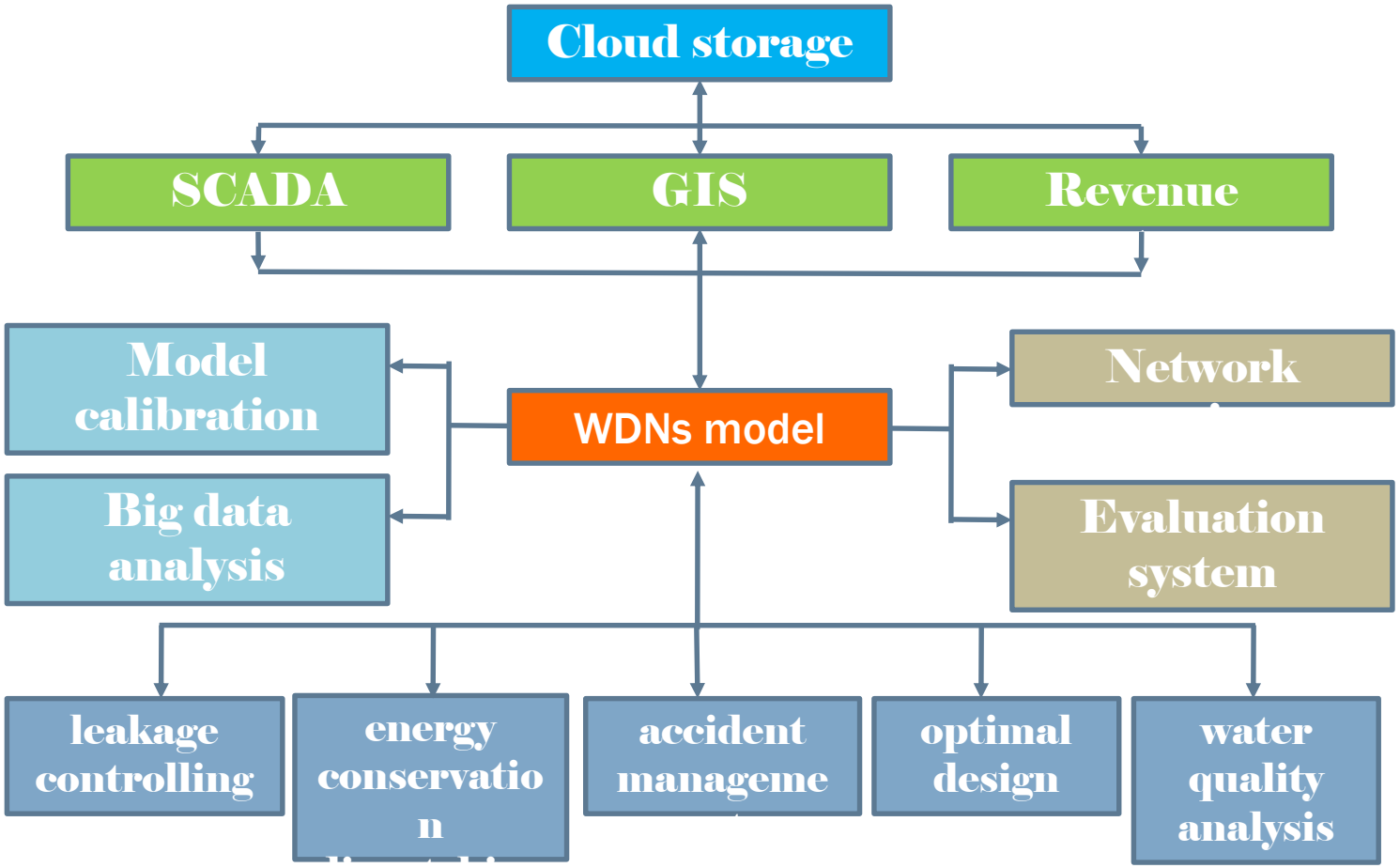
Build business systems and databases

Smart stage

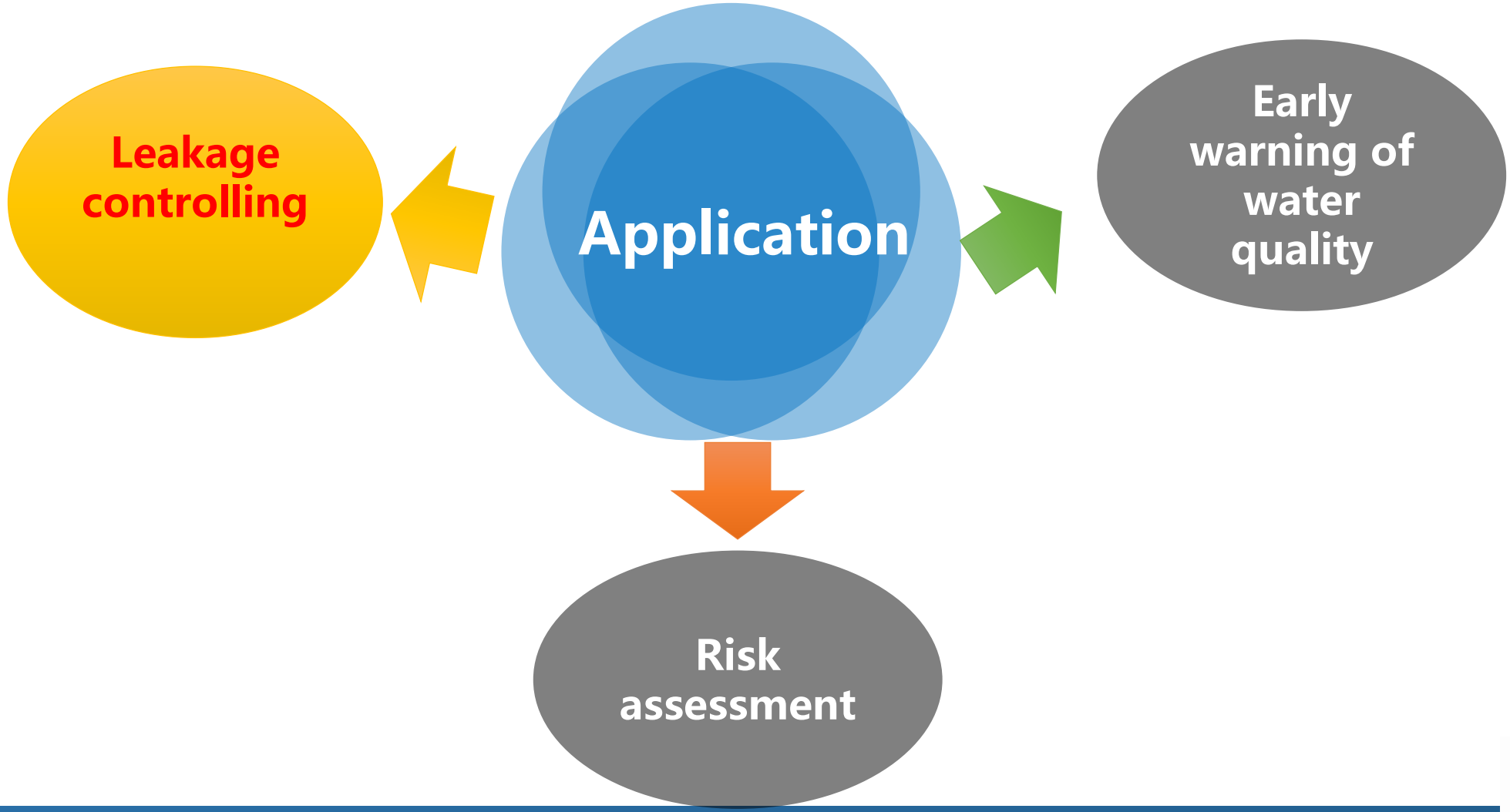
Combine the Internet of things, cloud computing,big data,mobile Internet and other new generation of information technology

1. Background

1.4 The framework of smart water in water distribution system



2. Application



2. Application

2.1 Leakage controlling

Mean difference test and Student's t test

District Metering Area, DMA

Minimum Night flow, MNF

Blind Source Separation，BSS

Leakage control of multi-source water distribution system by optimal pump schedule

Drop-restore Pressure Leakage Control

2. Application

2.1 Leakage controlling

2.1.1 Mean difference test and Student's t test

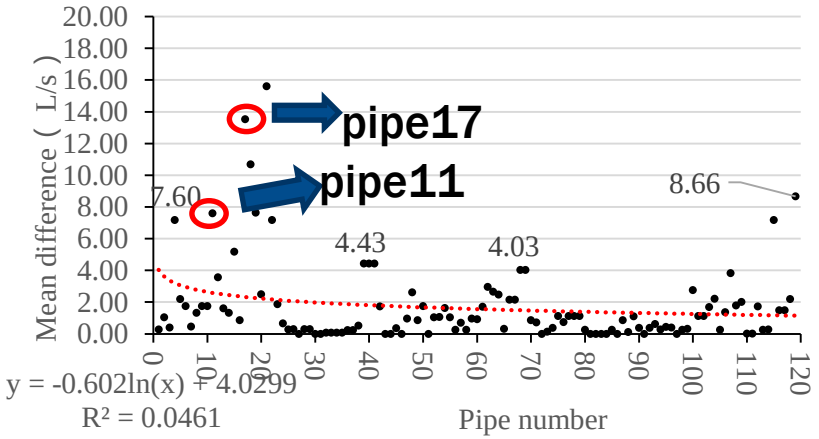
We believe that if there is a difference in daily water supply rate that means there may be leakage. Based on this assumption , if the daily flow data varies much, then we think the pipes around the monitoring leaks.

- Support vector machine
- Mean difference test
- Student's t test

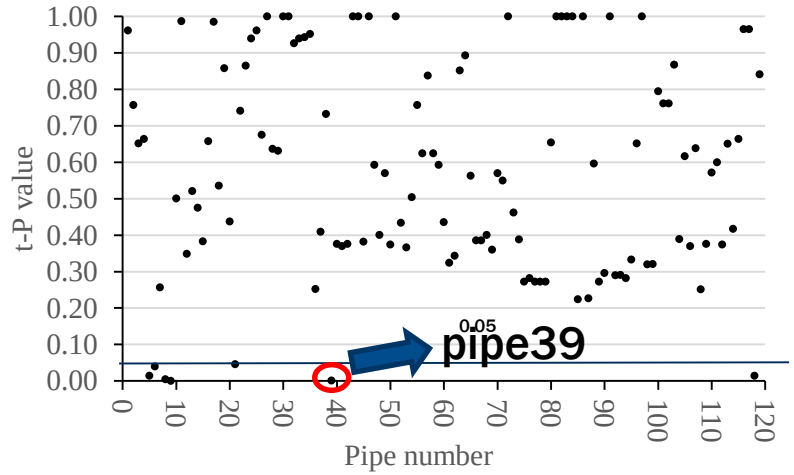
2. Application

2.1 Leakage controlling

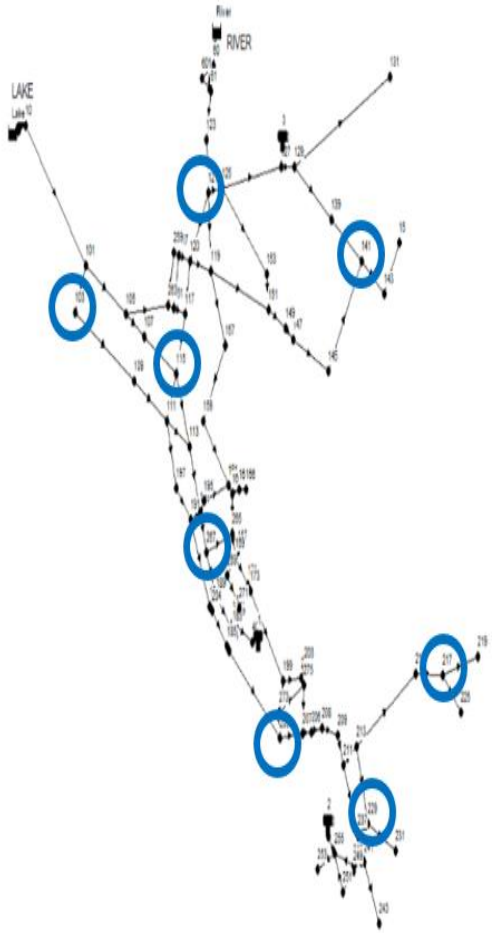
2.1.1 Mean difference test and Student's t test

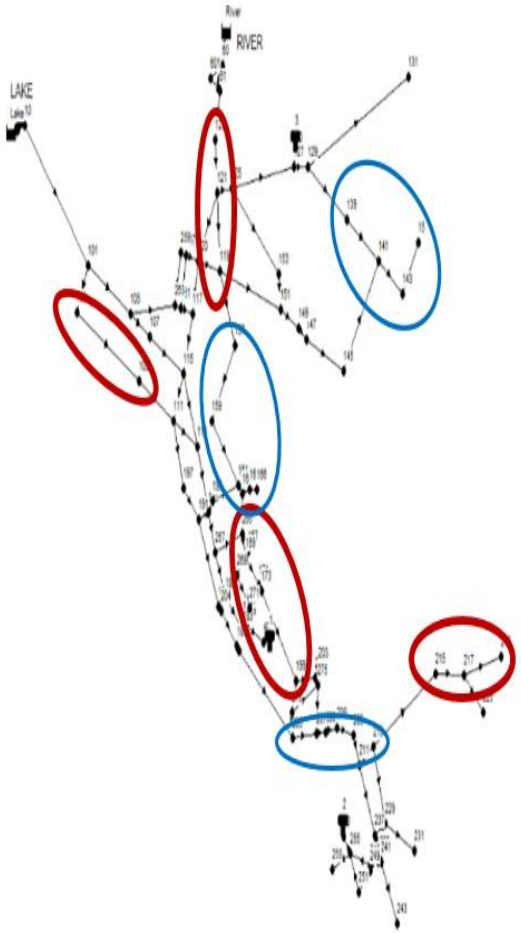


Pipe 14 leaks.
Pipe 14 connect with pipe 17、14、11、13.



Pipe 36 leaks.
Pipe 36 connect with pipe 39、40.





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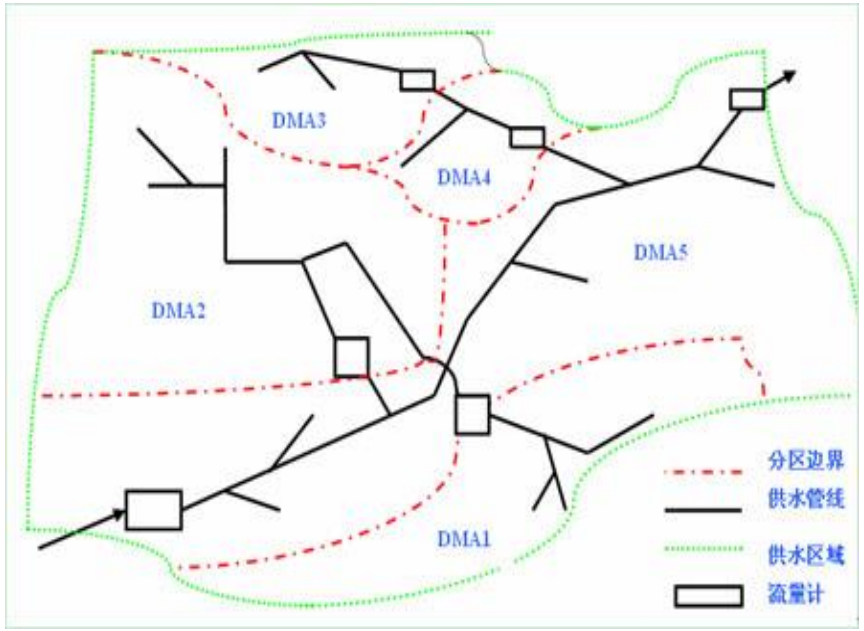
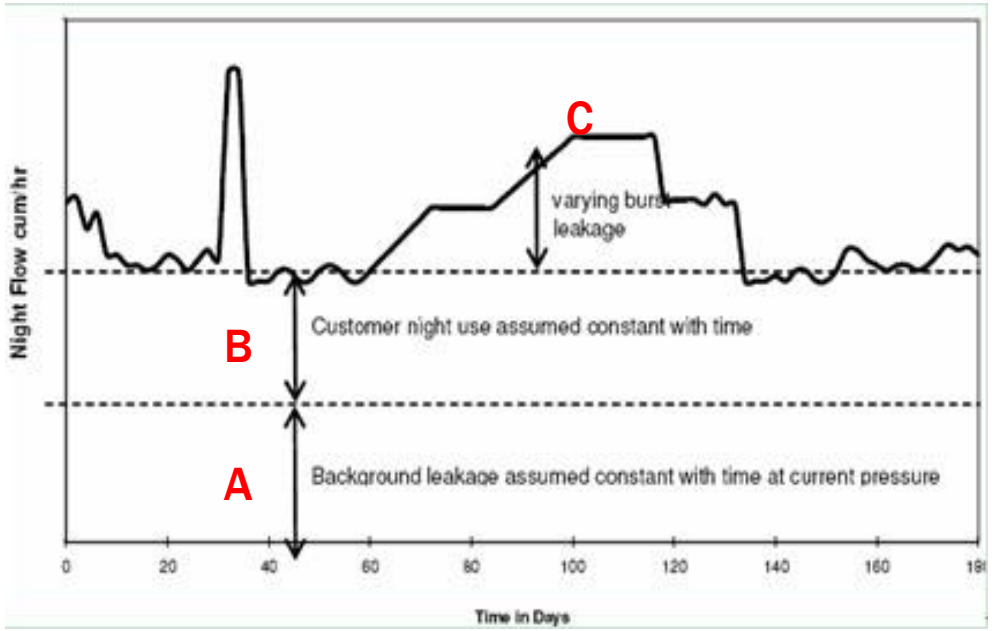
2.1 Leakage controlling

2.1.2 District Metering Area, DMA



Minimum Night flow, MNF



2. Application

2.1 Leakage controlling

Mean difference test and Student's t test

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Minimum Night flow, MNF

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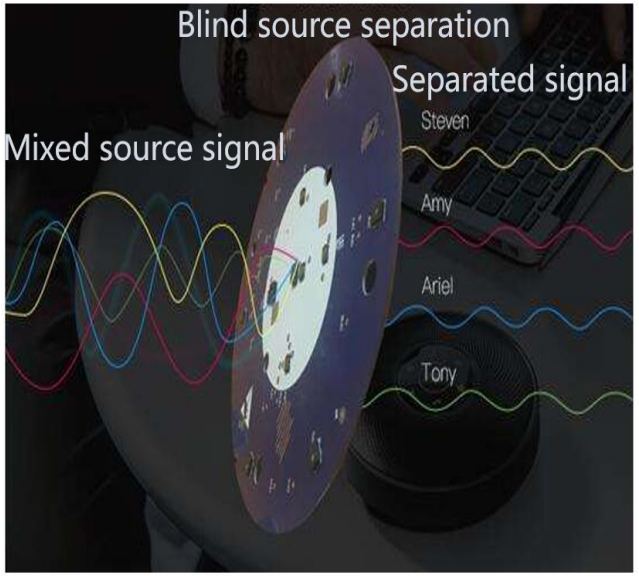
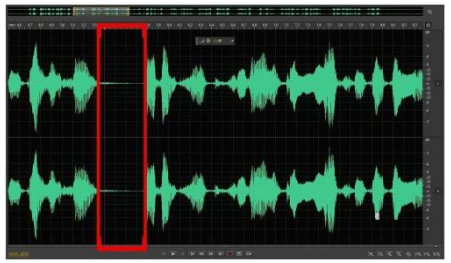
Drop-restore Pressure Leakage Control

2. Application

2.1 Leakage controlling

2.1.3 Blind Source Separation，BSS





·An integrated method of information theory, artificial neural networks and statistical signal processing.

·BSS can separate the mixed unknown sources about which we don't know how they mixed and what they are.

2. Application

2.1 Leakage controlling

2.1.3 Blind Source Separation，BSS

The observed signal x is gained by linear mixing the source signal S with mixing matrix A. By searching separation matrix W, the separated signal Y is obtained from the observation signal x, so that it can approach to S.

$$x = As$$

$$y = Wx = WAs = Gs$$

The basic leakage quantification model :

$$Q_T = Q_A + Q_L$$

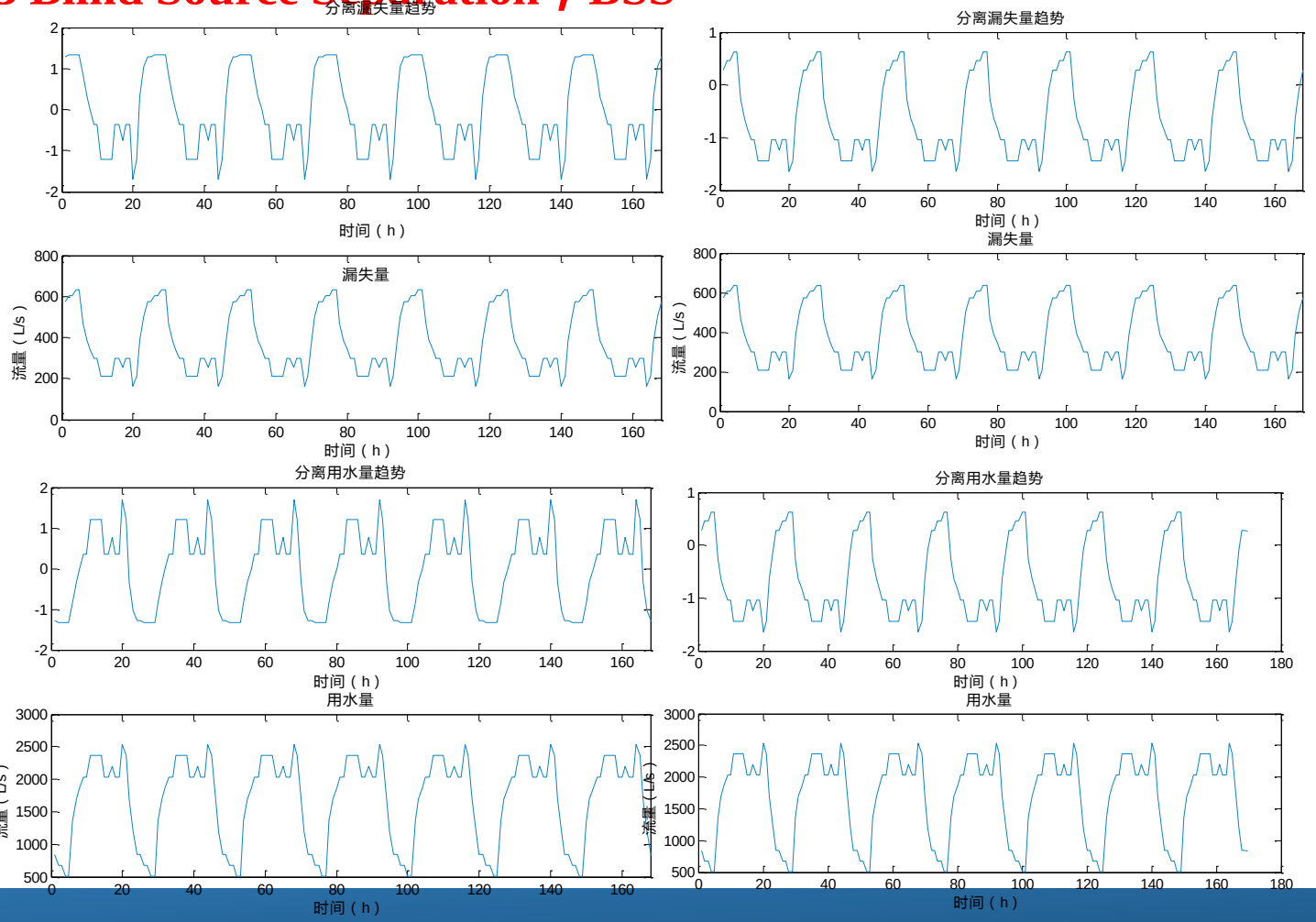
The amount of water consumption and leakage can be estimated only through observed inlet pressure and inlet flow signals, without any prior conditions

$$x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} Q \\ P \end{bmatrix}, S = \begin{bmatrix} S_1 \\ S_2 \end{bmatrix} = \begin{bmatrix} q_c \\ q_l \end{bmatrix}, A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$$

2. Application

2.1 Leakage controlling

2.1.3 Blind Source Separation，BSS



The trend of the separated leakage signal

True leakage value signal

The trend of the separated water use signal

True water use signal

2. Application

2.1 Leakage controlling

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Leakage control of multi-source water distribution system by optimal pump schedule

Drop-restore Pressure Leakage Control

2. Application

2.1 Leakage controlling

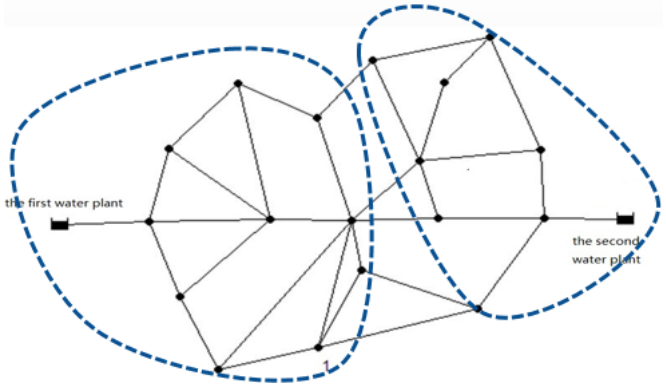
2.1.4 Leakage control of multi-source water distribution system by optimal pump schedule

(1) The city's water supply pattern develops from a single water source to multiple ones.

(2)This trend makes the unbalance between water supply and demand, which causes some problems:

- cause waste of energy;
- produce excessive pressure;
- increase the amount of leakage.

Therefore, it is necessary to have a pump optimal schedule for the water supply system in a reasonable way to reduce power consumption and leakage.



2. Application

2.1 Leakage controlling

2.1.4 Leakage control of multi-source water distribution system by optimal pump schedule

water supply network partition model

pump optimal scheduling model

Build multi-source water distribution system pump optimal leakage control model

- solve multi-objective problem;
- optimal partition schedule, separated valves and pump optimal schedule would be decided.

2. Application

2.1 Leakage controlling

2.1.4 Leakage control of multi-source water distribution system by optimal pump schedule

An example of leakage control project of water supply system in HD city

Basic information about water supply system in HD city

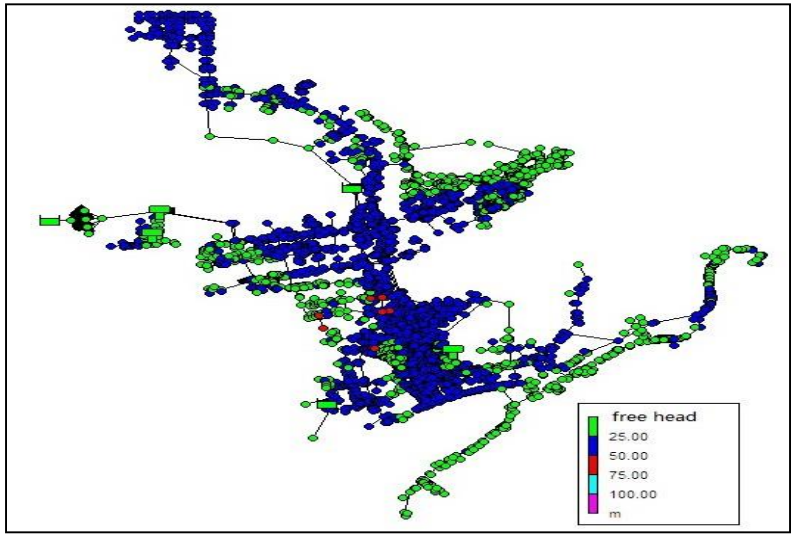
HD city is a multi-source water distribution system, which has three water plants and 12 pumps. There are more than 4,000 pipe sections in this system, across 507km, together with 1022 valves, 10 pressure monitoring points, and the maximum pipe diameter is DN1000, the minimum is DN100. The majority pipe diameter is DN300. HD city's terrain goes through ups and downs, the maximum elevation difference is 90m, the whole terrain trend is from high west to low east. The water supply network topology of HD city is shown in Fig. 3.

2. Application

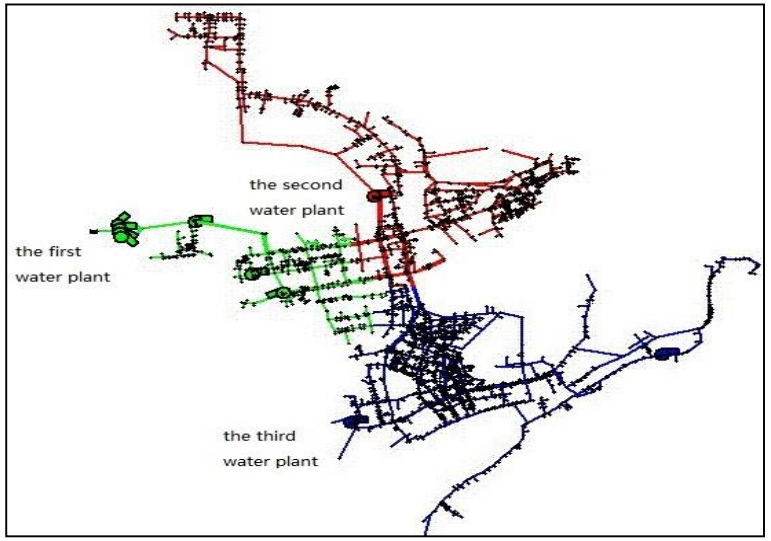
2.1 Leakage controlling

2.1.4 Leakage control of multi-source water distribution system by optimal pump schedule

HD city's water supply schedule can be divided into three periods. The first period: 6:00 to 13:00pm; the second period: 14:00 to 21:00; the third period :22:00 to 5:00. After partition and schedule, free head distribution and regional distribution of water supply is shown in the figure below.



Free head distribution of water supply



Regional distribution of water supply

- The average pressure of entire network changed from 50.3 m to 46.2 m,
- The leakage rate changed from 11% to 8.6%, power consumption was reduced by 0.32%.

2. Application

2.1 Leakage controlling

Mean difference test and Student's t test

District Metering Area, DMA

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Blind Source Separation，BSS

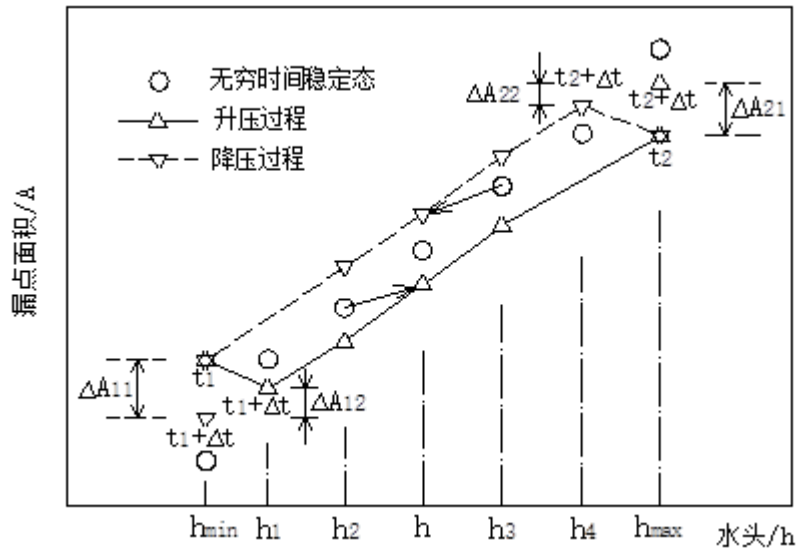
Leakage control of multi-source water distribution system by optimal pump schedule

Drop-restore Pressure Leakage Control

2. Application

2.1 Leakage controlling

2.1.5 Drop-restore Pressure Leakage Control



When studying the axial crack characteristics of PE pipes, our research group found that for the same head, the area of the leak in the process of pressure rise is smaller than that in the process of pressure drop. Relative to steady state, the area of leakage in the pressure rise increased by 10%, and the area of pressure drop processes decreased by 40%, respectively.

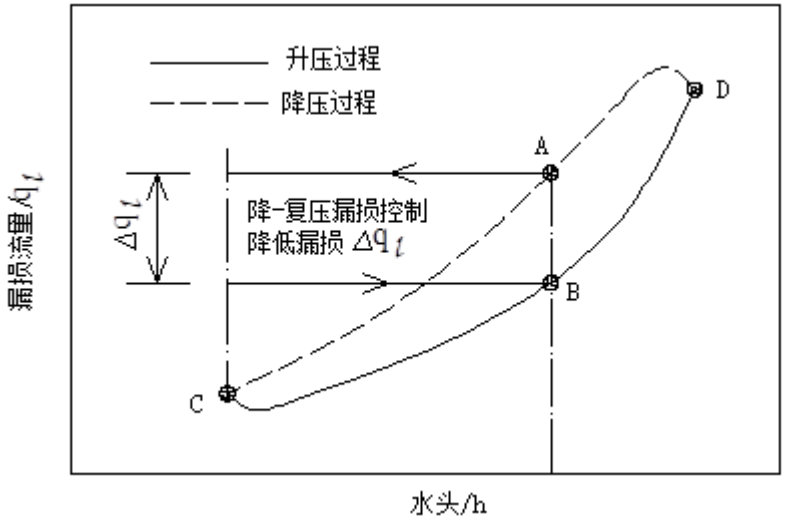
2. Application

2.1 Leakage controlling

2.1.5 Drop-restore Pressure Leakage Control

Drop-restore mechanism is dropping and restoring head quickly that changes the pipeline from a high-leakage state to a lower-leakage state and achieve the purpose of reducing leakage quantity without changing average pressure.

Compared with existing pressure reducing method， this method is more refined in leakage controlling.



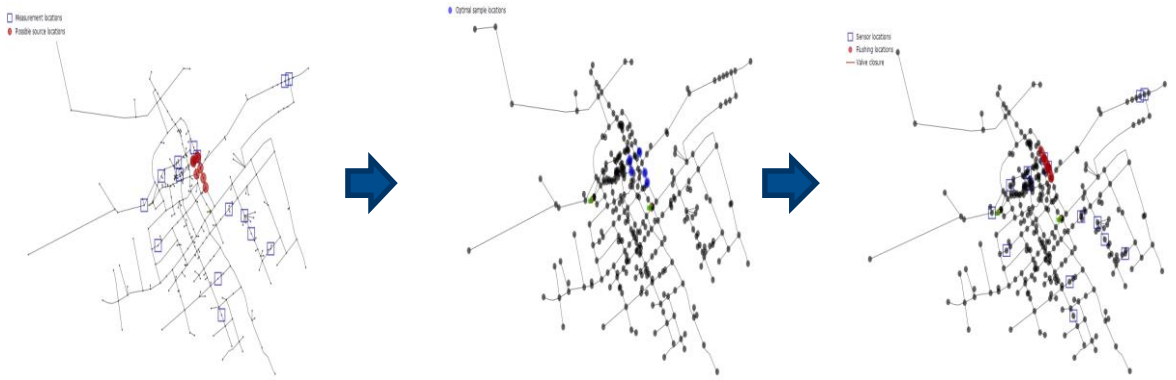
2. Application

2. Application

2.2 Early warning of water quality

An early warning of water quality system is used to **detect random contamination events** and to **provide information on the location of the contaminants** within the system. So that we can take action to recover the quality of the water supply system.

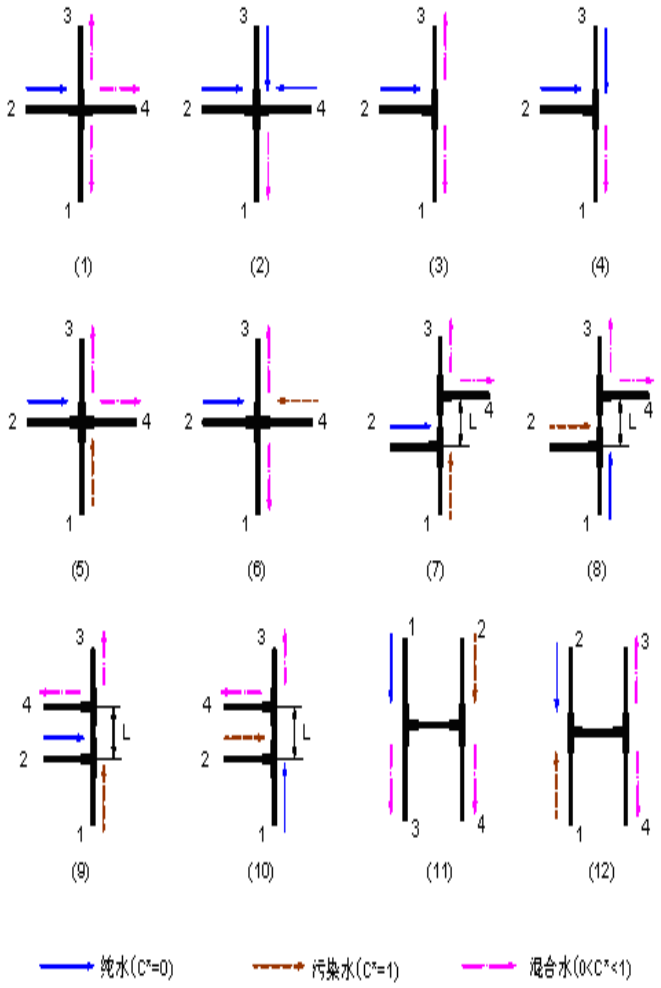
- **Sensor placement**
- **Event detection**
- **Contaminant source identification**
- **Response**
- **Recovery**

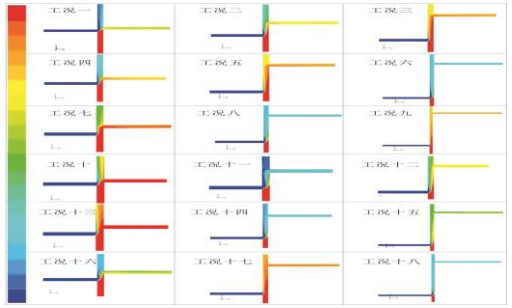


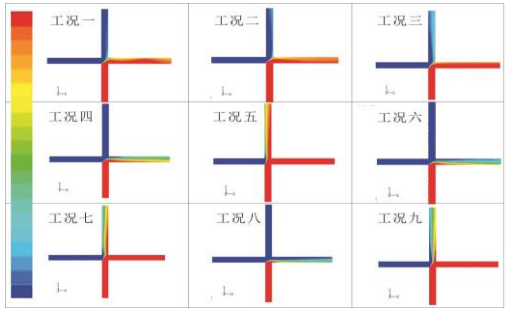
Based on the accuracy of the water quality model.

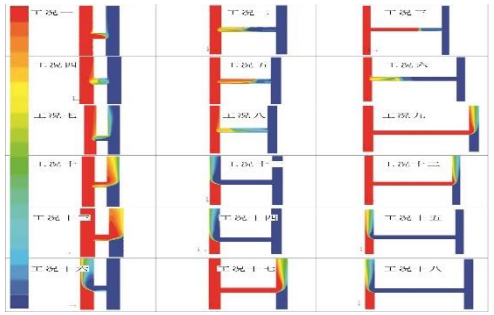
2. Application

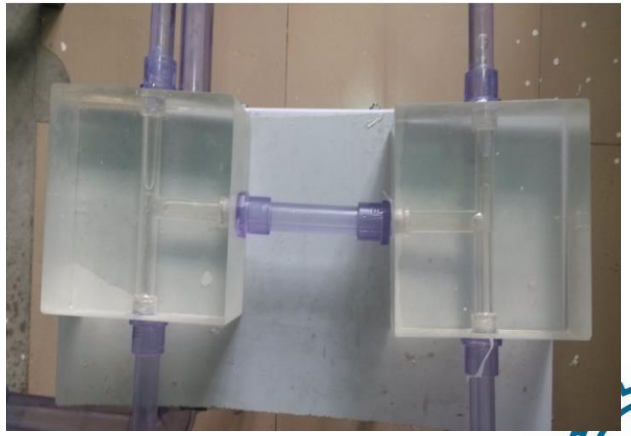
2.2 Early warning of water quality





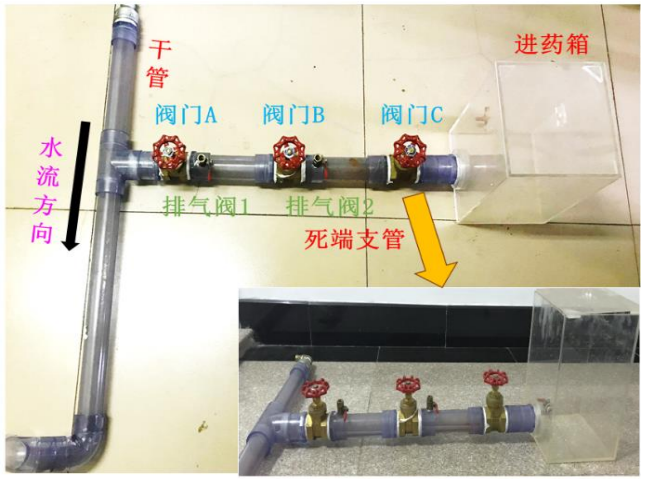


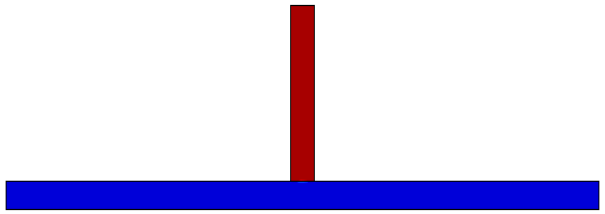


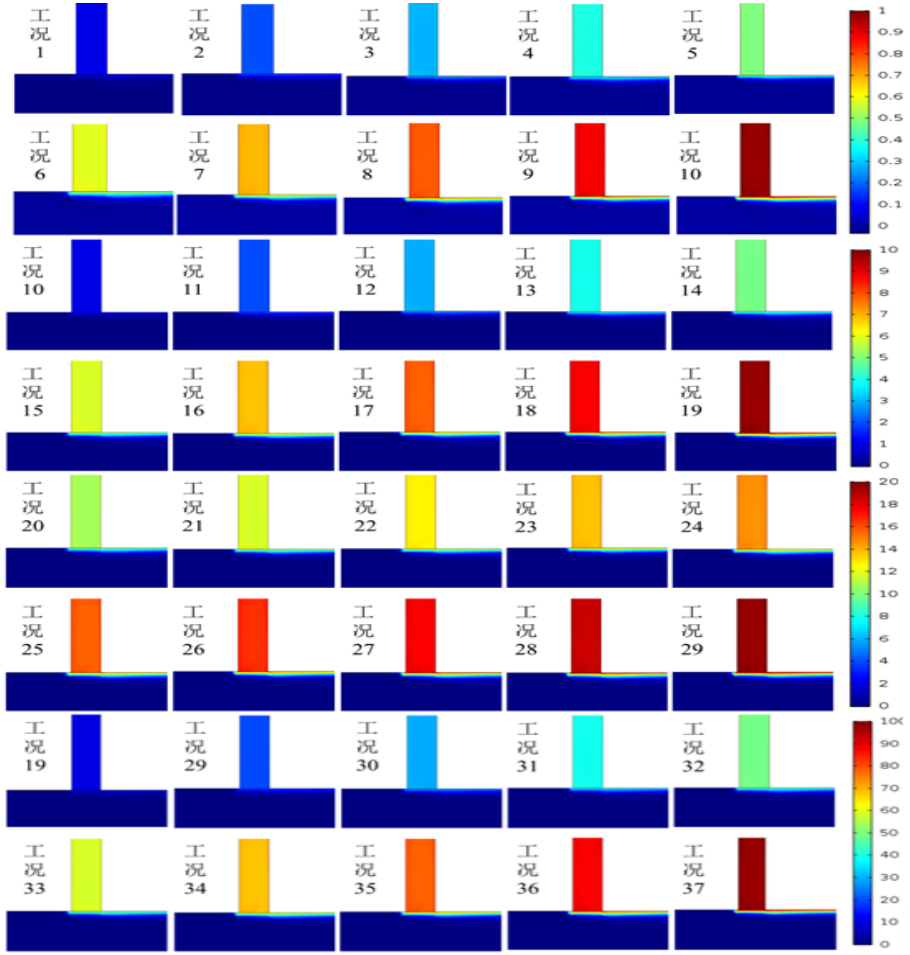


2. Application

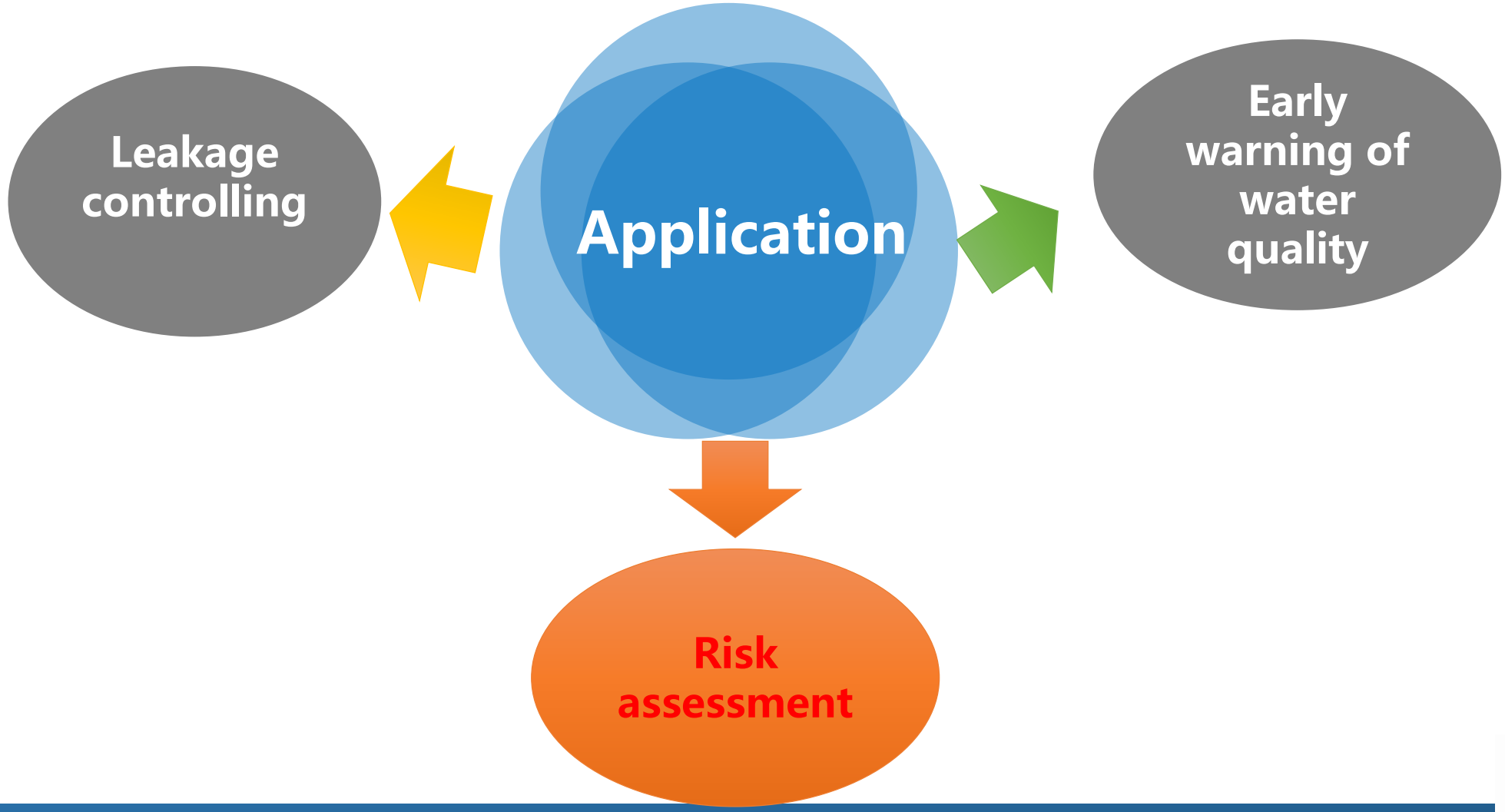
2.2 Early warning of water quality







2. Application



2. Application

2.3 Risk assessment

A Case Study on Risk Assessment of Long Distance Water Supply System

Design flow of water transmission project M is 954,800m^3/d, and water is transmitted by parallel pipeline with gravity flow to H city.

Length of one pipeline: 176.33 km

Flow of each pipeline: 477,400 m^3/d

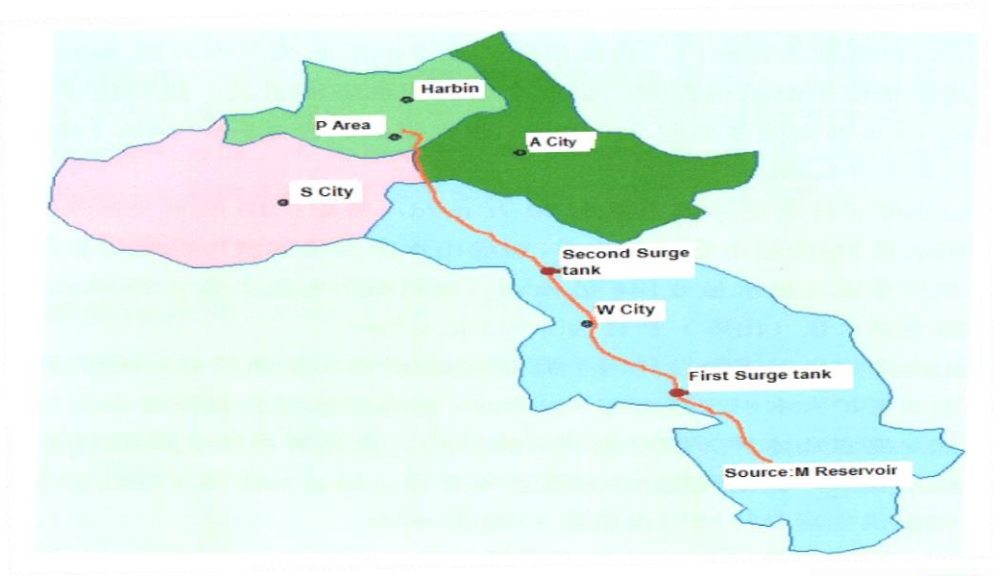
Diameter : 2,200 mm

Reservoir level : highest-323.26 m; lowest-298 m; normal-318 m

Four throttle control valves along each pipe uniformly

Two surge tanks : 38+350.350 m and 100+839.220 m

Air valves : 439 ; Butterfly valves for repairs : 68 ; Butterfly valves for connection : 12



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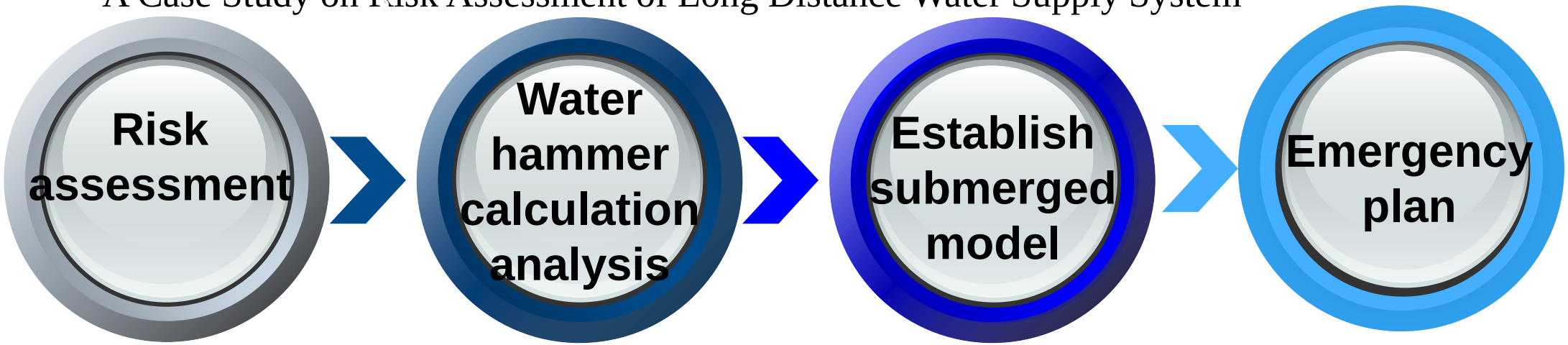
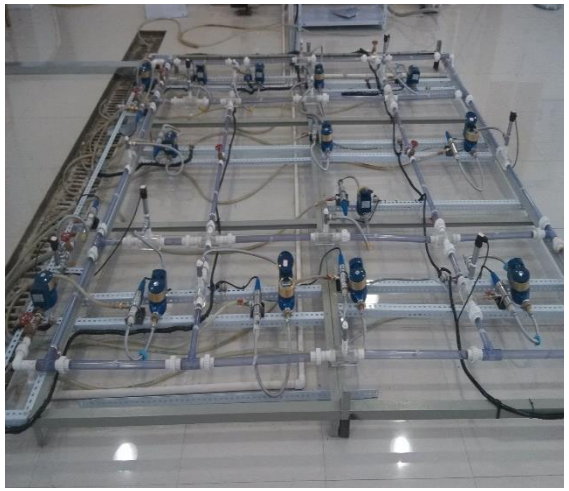


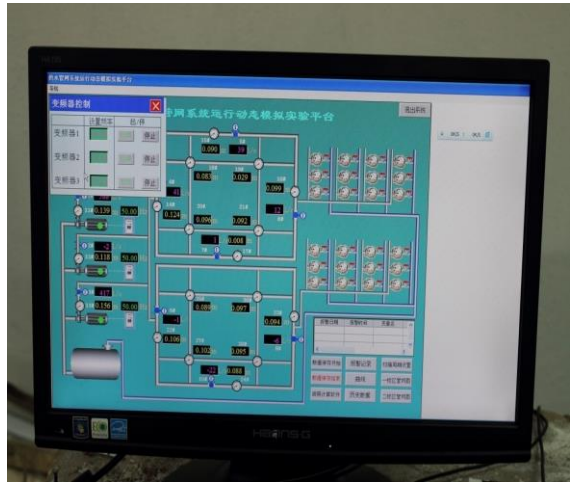
3. Research group

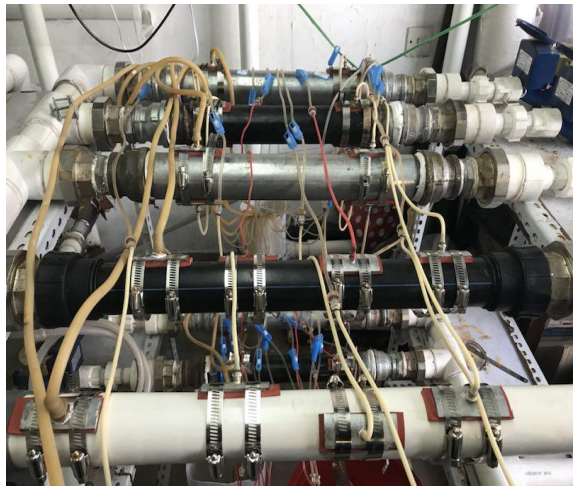
Assoc. Prof Post doctor	**Jin Liang Gao**	Mobile	(+86) 13936477968
Harbin Institute of Technology		E-mail	gjl@hit.edu.cn

- Participated in the eu's seventh framework, “Marie Curie action” plan
- The England royal society exchange fund
- Natural Science Foundation of China
- National “11th five years’ plan " special water projects
- Published many Chinese and English research papers, and work as a chief editor in the compilation of 3 Chinese and English works.
- Software copyright 3, approved 17 invention patents.

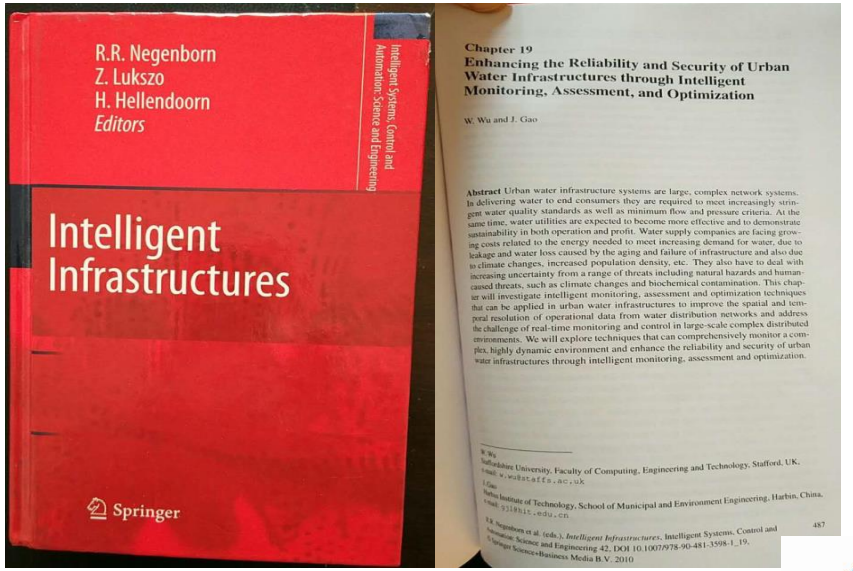
3. Research group





3. Research group




Thank you !