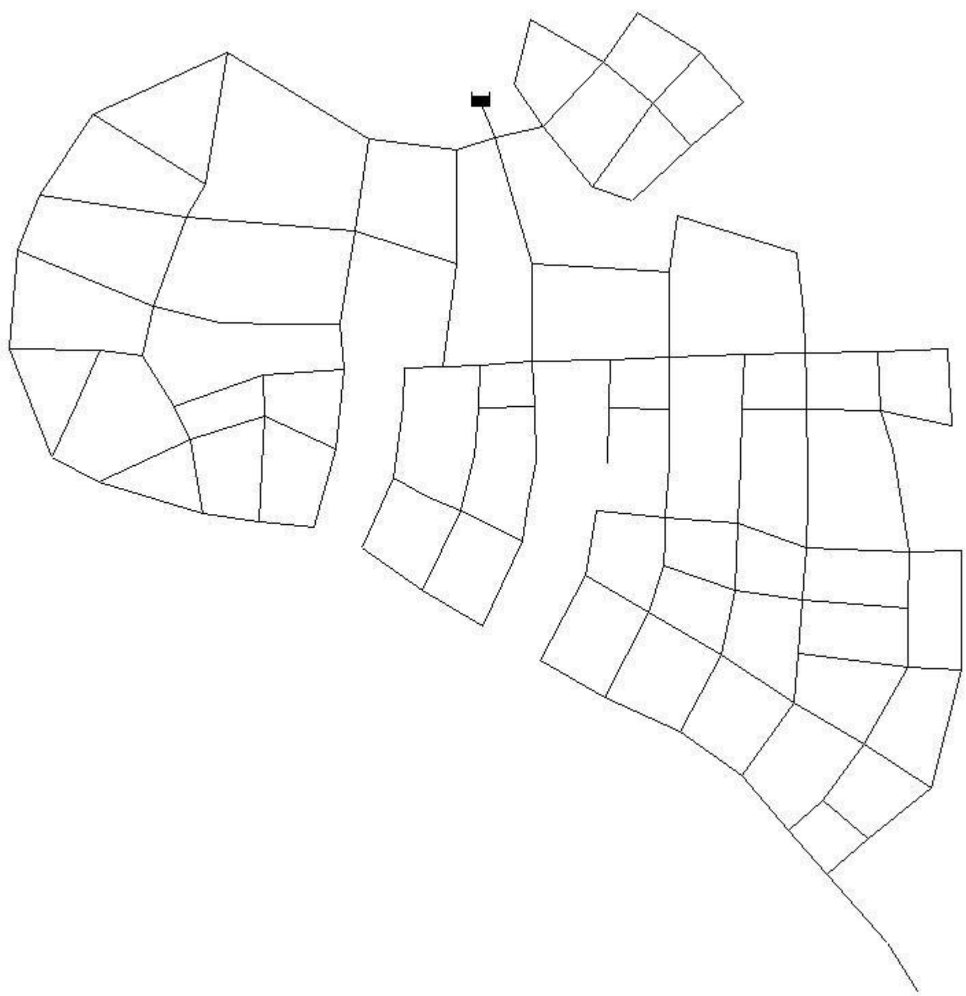
SYSTEM ID: Zhi Jiang

NARRATIVE DESCRIPTION

The Zhi Jiang system is a simplified version of the Zhi Jiang water distribution system in the eastern province of China. The system has an average demand of 484,000 CMD. The network was first presented by Zheng et al. (2011) as part of a design and optimization study. A general schematic of the system is shown below. The system has one reservoir and 126 kilometers of pipe.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The Zhi Jiang system was originally developed by Zheng et al. (2011) using non-linear programming and differential evolution approach. It has since been optimized further by incorporating domain knowledge into a genetic algorithm model (Bi et al., 2014).

ORIGINAL REFERENCE:

Zheng, Feifei, Simpson, Angus R & Zecchin, Aaron C, 2011. A combined NLP-differential evolution algorithm approach for the optimization of looped water distribution systems. Water resources research, 47(8), https://doi.org/10.1029/2011WR010394

ABSTRACT: This paper proposes a novel optimization approach for the least cost design of looped water distribution systems (WDSs). Three distinct steps are involved in the proposed optimization approach. In the first step, the shortest-distance tree within the looped network is identified using the Dijkstra graph theory algorithm, for which an extension is proposed to find the shortest-distance tree for multisource WDSs. In the second step, a nonlinear programming (NLP) solver is employed to optimize the pipe diameters for the shortest-distance tree (chords of the shortest-distance tree are allocated the minimum allowable pipe sizes). Finally, in the third step, the original looped water network is optimized using a differential evolution (DE) algorithm seeded with diameters in the proximity of the continuous pipe sizes obtained in step two. As such, the proposed optimization approach combines the traditional deterministic optimization technique of NLP with the emerging evolutionary algorithm DE via the proposed network decomposition. The proposed methodology has been tested on four looped WDSs with the number of decision variables ranging from 21 to 454. Results obtained show the proposed approach is able to find optimal solutions with significantly less computational effort than other optimization techniques.

ADDITIONAL REFERENCES:

Bi, W., Dandy, G. C. and Maier, H. R. (2015) Improved genetic algorithm optimization of water distribution system design by incorporating domain knowledge, Environmental Modelling & Software, Vol. 69, 370-381.

ADDITIONAL CITATIONS:

The original publication of Zi Jiang (20011) and by inference the Zhi Jiang system have been cited by 63 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: 63 Citations. The subsequent citation by Bi et al. (2015) was cited by 144 authors: 144 Citations.

AVAILABLE INFORMATION

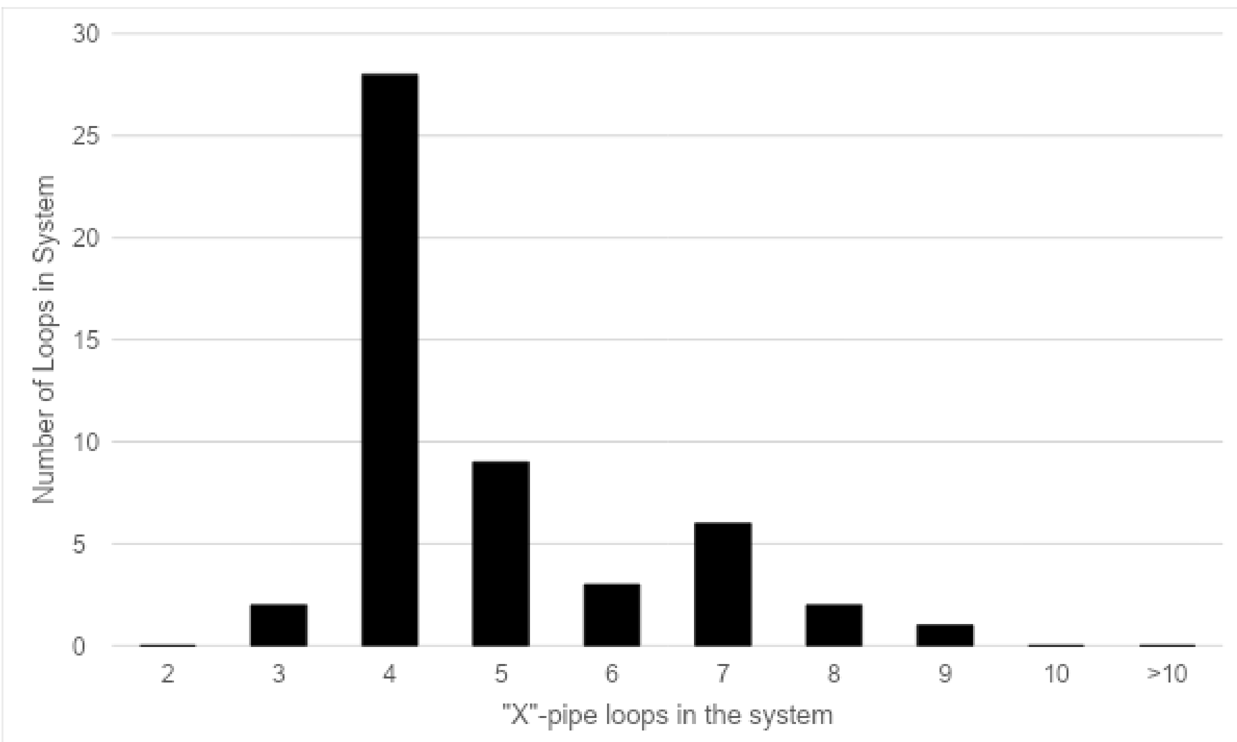
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	No
Background map	No
Elevation data	Yes
Pipe data	Yes
Pipe material	No
Pipe age	No
Pipe pressure class	No
Nominal or actual diameters	Nominal
Pump data	NA
Useful horsepower	
Pump operating curves	
Tank data	NA
Elevation data	
Stage storage curves	
Water quality information	
Valve data	NA
PRV/FCV data	
Isolation valve data	
Hydrant data	
Demand data	Yes
Total system demand	No
Nodal demand data	Yes
Temporal data demands	No
System leakage	No
Hydraulic data	No
Hydraulically calibrated model	
Field hydraulic calibration data	
Water quality data	No
Disinfection method	
Chlorine residual data	
Booster station data	
Fluoride/Chloride field data	
Water quality calibrated model	
Operational data	No
SCADA datasets	
Operational rules	

SYSTEM CLASSIFICATION:

PIPE/LOOP HISTOGRAM:

Hoagland et al. (2015) designed a network classification algorithm for use in classifying water distribution systems as either “branched,” “looped,” or “gridded” based on the observed frequency of network loops with different numbers of distinct pipe segments. The frequency distribution for the Zhi Jiang system is provided below. Using this information, Hoagland et al., classified this system as being a GRIDDED system.

# Total Pipes:	164
# Branch Pipes:	5
Ratio (Branch Pipes / Total Pipes):	0.03



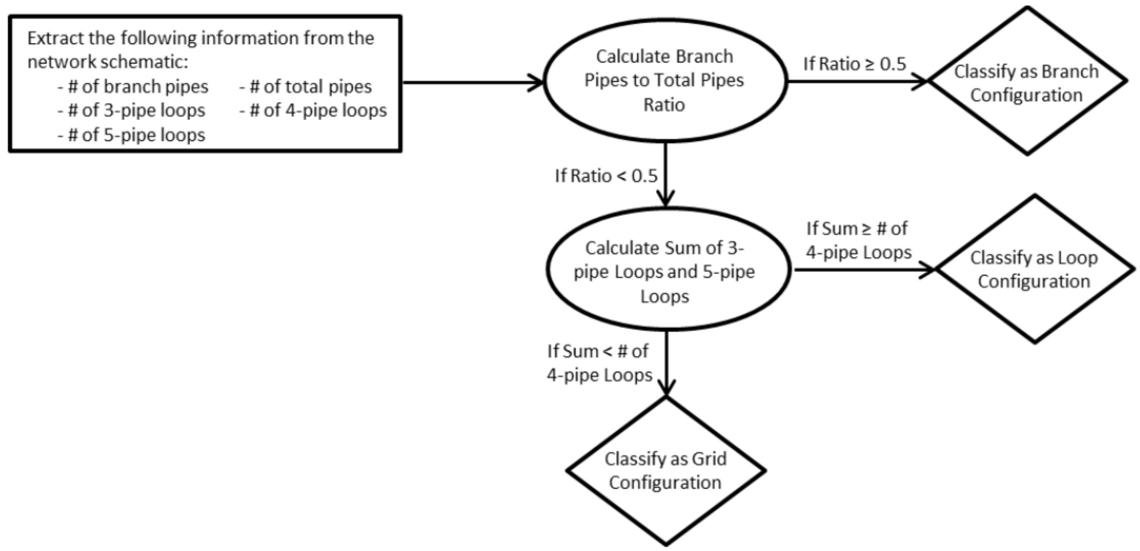


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

Hoagland, Steven & Schal, Stacey & Ormsbee, Lindell & Bryson, Lindsey. (2015). Classification of Water Distribution Systems for Research Applications. 696-702. 10.1061/9780784479162.064.

NETWORK STRUCTURE METRICS:

Building on the work of Hoagland et al., (2015), Hwang & Lansey (2017) created an expanded classification system that allow for further classification of a system as being either a transmission or distribution branched, looped, gridded, or hybrid system. Their algorithm streamlines the classification system by removing unnecessary nodes that do not contribute to the structure of the system while still retaining their use as intermediate points for demand data entry. A full description of the algorithm can be found in the cited reference.

Application of the Hwang and Lansey classification algorithm to the system yields the following statics and associated classification:

Parameter	Value
Edges	164
Pipes	164
Nodes	114
Average Diameter	600
Reduced Nodes	77
Reduced Edges	127
Branched Edges	4
Branched Index	0.0
Meshed Connectedness	0.2
Reduced Meshed Connectedness	0.34
Link Density	0
Average Node Degree	2.9
Hwang & Lansey Classification	Transmission Dense-Loop

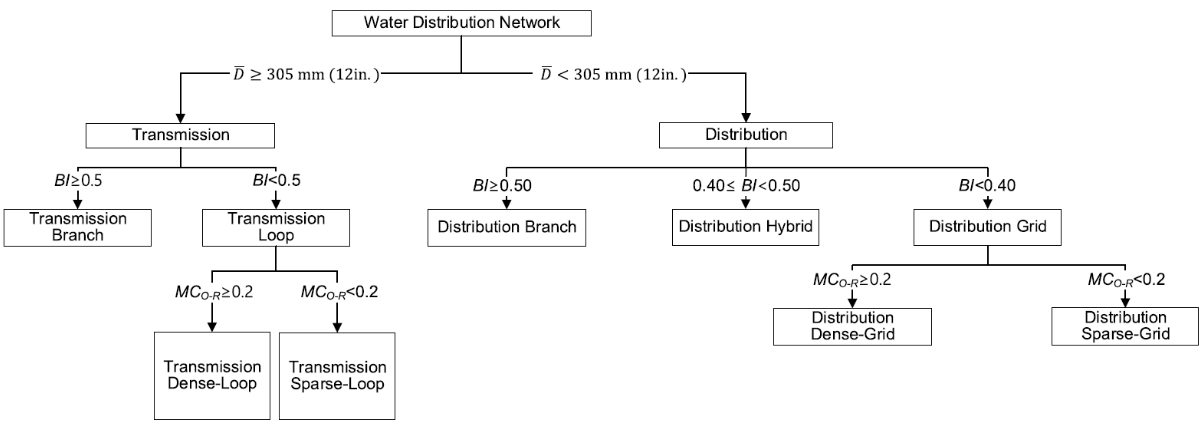


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

Hwang H. & Lansey, K. (2015) "Water distribution system classification using system characteristics and graph theory metrics." *Journal of water resource planning and management* 143(12) https://doi.org/10.1061/(ASCE)WR.1943-5452.0000850

DETAILED DATA SUMMARIES

PHYSICAL ASSETS:

Asset Type:	# of Assets
Master Meters	0
Tanks	0
Pumps	0
Water Sources	1

NETWORK CHARACTERISTICS:

# Total Pipes:	164
# Junctions	113
# Reservoirs	1
# Tanks	0
# Regulating Valves	0
# Isolation Values	0
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (mm)	Length (m)
600	126436

PUMP DATA:

Pump Horsepower	NO
Pump Curves:	NO

DATA FILE ATTRIBUTES:

ATTRIBUTE		UNITS
Pipe Length & Diameter	X	Meters and Millimeters
Pipe Age		
Node Elevation	X	Meters
Node Demand	X	LPS
Valves		
Hydrants		
Tank Levels		
Tank Volume		
PRVs		
WTP		
WTP Capacity		
Pump Data		