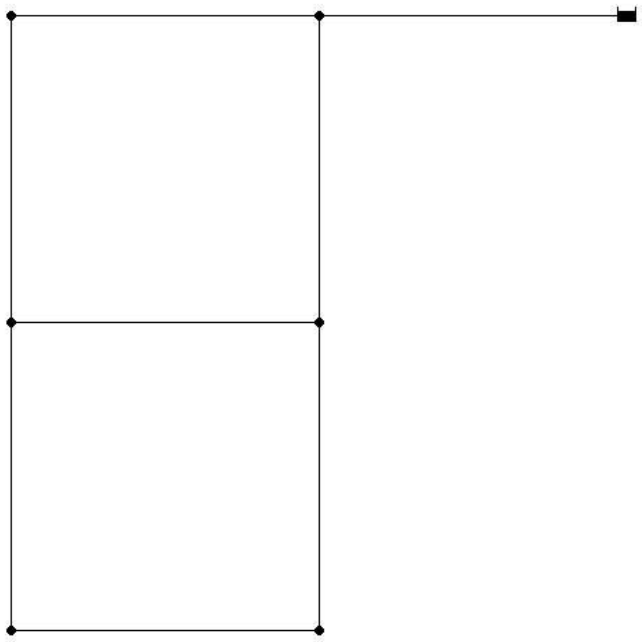
SYSTEM ID: Two Loops

NARRATIVE DESCRIPTION

The Two Loop system is a simple example network made of eight pipes configured into two loops. It is fed from one reservoir by gravity and has 8 km of pipe. It was originally published by Alperovits & Shamir (1977) to optimize the design of distribution systems using the linear programming gradient method. Pipe diameters come from Table 5a: Loop 1 in the original reference file. A general schematic of the system is shown below.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The network was first published by Alperovits & Shamir (1977) and has since been frequently used for design optimization modelling in literature. The original citation and abstract are listed below.

ORIGINAL REFERENCE:

Alperovits, Elyahu, and Uri Shamir. "Design of optimal water distribution systems." *Water resources research* 13.6 (1977): 885-900.

ABSTRACT: A method called linear programing gradient (LPG) is presented, by which the optimal design of a water distribution system can be obtained. The system is a pipeline network, which delivers known demands from sources to consumers and may contain pumps, valves, and reservoirs. Operation of the system under each of a set of demand loadings is considered explicitly in the optimization. The decision variables thus include design parameters, i.e., pipe diameters, pump capacities and reservoir elevations, and operational parameters, i.e., the pumps to be operated and the valve settings for each of the loading conditions. The objective function, to be minimized, reflects the overall cost capital plus present value of operating costs. The constraints are that demands are to be met and pressures at selected nodes in the network are to be within specified limits. The solution is obtained via a hierarchical decomposition of the optimization problem. The primary variables are the flows in the network. For each flow distribution the other decision variables are optimized by linear programing. Postoptimality analysis of the linear program provides the information necessary to compute the gradient of the total cost with respect to changes in the flow distribution. The gradient is used to change the flows so that a (local) optimum is approached. The method was implemented in a computer program. Solved examples are presented.

ADDITIONAL CITATIONS:

The original publication by Alperovits & Shamir (1977) and by inference the Two Loop system have been cited by 1070 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: 1070 Citations.

AVAILABLE INFORMATION

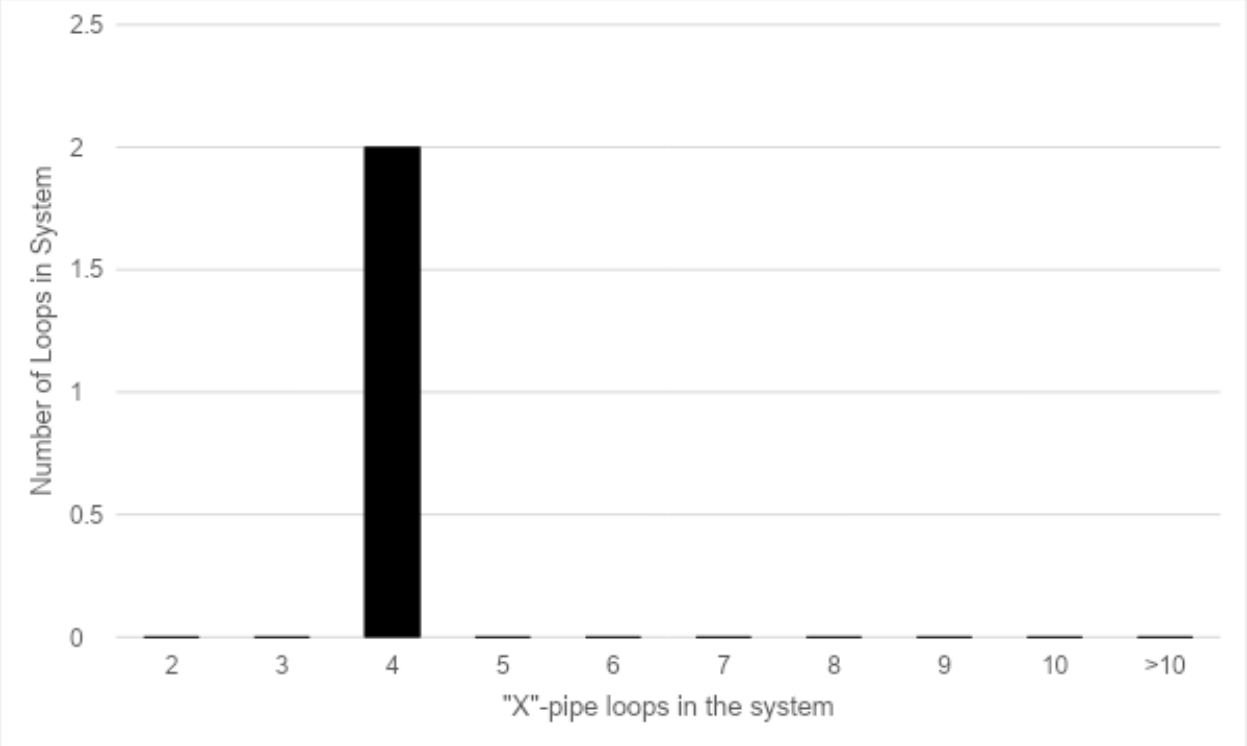
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	No
Background map	No
Elevation data	Yes
Pipe data	Yes
Pipe material	No
Pipe age	No
Pipe pressure class	No
Nominal or actual diameters	Nominal
Pump data	N.A.
Useful horsepower	
Pump operating curves	
Tank data	N.A.
Elevation data	
Stage storage curves	
Water quality information	
Valve data	N.A.
PRV/FCV data	
Isolation valve data	
Hydrant data	
Demand data	Yes
Total system demand	Yes
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 Two Loop system is provided below. Using this information, Hoagland et al., classified this system as being a GRIDDED system.

# Total Pipes:	8
# Branch Pipes:	1
Ratio (Branch Pipes / Total Pipes):	0.125



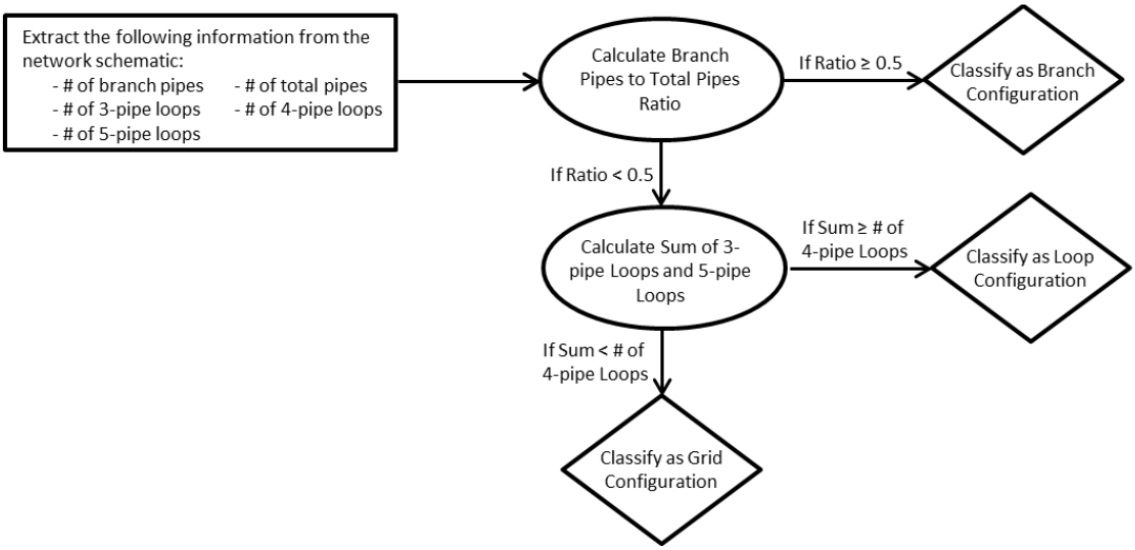


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

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 allows 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	8
Pipes	8
Nodes	7
Average Diameter	280
Reduced Nodes	3
Reduced Edges	4
Branched Edges	1
Branched Index	0.2
Meshed Connectedness	0.2
Reduced Meshed Connectedness	2
Link Density	0.4
Average Node Degree	2.3
Hwang & Lansey Classification	Distribution Dense-Grid

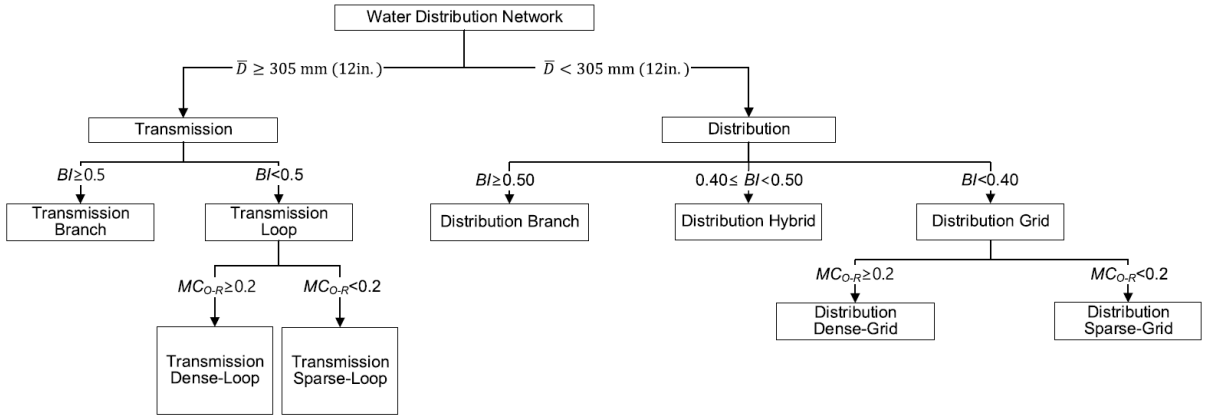


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

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

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

NETWORK CHARACTERISTICS:

# Total Pipes:	8
# Junctions	6
# Reservoirs	1
# Tanks	0
# Regulating Valves	Unknown
# Isolation Values	Unknown
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (mm)	Length (m)
153	3000
203	1000
254	1000
406	1000
457	2000

PUMP DATA:

Pump Horsepower	NO
Pump Curves:	NO

DATA FILE ATTRIBUTES:

ATTRIBUTE		UNITS
Pipe Length & Diameter	X	Meters & Millimeters
Pipe Age		
Node Elevation	X	Meters
Node Demand	X	Cubic meters/hour
Valves		
Hydrants		
Tank Levels		
Tank Volume		
PRVs		
WTP		
WTP Capacity		
Pump Data		