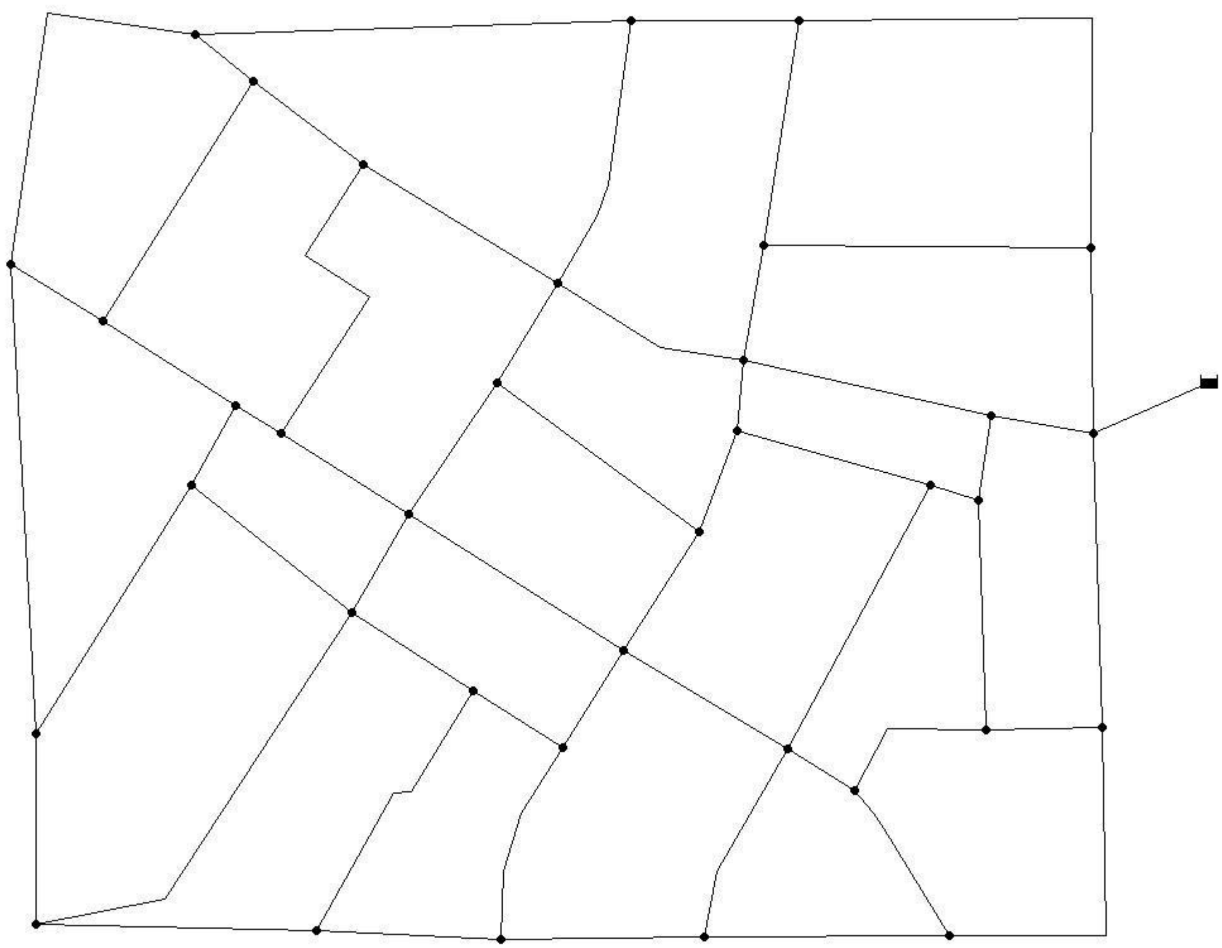
SYSTEM ID: Fossolo

NARRATIVE DESCRIPTION

The Fossolo system is based on the water distribution system for the Fossolo neighborhood in Bologna, Italy. The system has an average demand of 3,000 CMD. The network was first presented by Bragalli et al. (2008) as part of a design study. A general schematic of the system is shown below. The system has one reservoir and 8.4 kilometers of pipe.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The Fossolo system was originally developed by Bragalli et al. (2011) using mixed integer nonlinear programming. Since then, it was optimized in various studies using the multi-objective hybrid approach (Creach & Fanchini, 2014) and by incorporating domain knowledge into a genetic algorithm model (Bi et al., 2014).

ORIGINAL REFERENCE:

Bragalli, C. Ambrosio, D., Lee, J., Lodi, A., Toth, P. 2008. IBM Research Report: Water Network Design by MINLP. RC24495 (W0802-056)
https://dominoweb.draco.res.ibm.com/ef1b90113cc7b03a852573fc00529261.html

ABSTRACT: A new computer model called Genetic Algorithm Pipe Network Optimization Model (GENOME) has been developed with the aim of optimizing the design of new looped irrigation water distribution networks. The model is based on a genetic algorithm method, although relevant modifications and improvements have been implemented to adapt the model to this specific problem. It makes use of the robust network solver EPANET. The model has been tested and validated by applying it to the least cost optimization of several benchmark networks reported in the literature. The results obtained with GENOME have been compared with those found in previous works, obtaining the same results as the best published in the literature to date. Once the model was validated, the optimization of a real complex irrigation network was carried out to evaluate the potential of the genetic algorithm for the optimal design of large-scale networks. Although satisfactory results have been obtained, some adjustments would be desirable to improve the performance of genetic algorithms when the complexity of the network requires it.

ADDITIONAL REFERENCES:

Creaco, E. and Franchini, M. (2014) Low level hybrid procedure for the multi-objective design of water distribution networks, Procedia Engineering 70, 369 – 378

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 Bragalli (2008) and by inference the Fossolo 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.

AVAILABLE INFORMATION

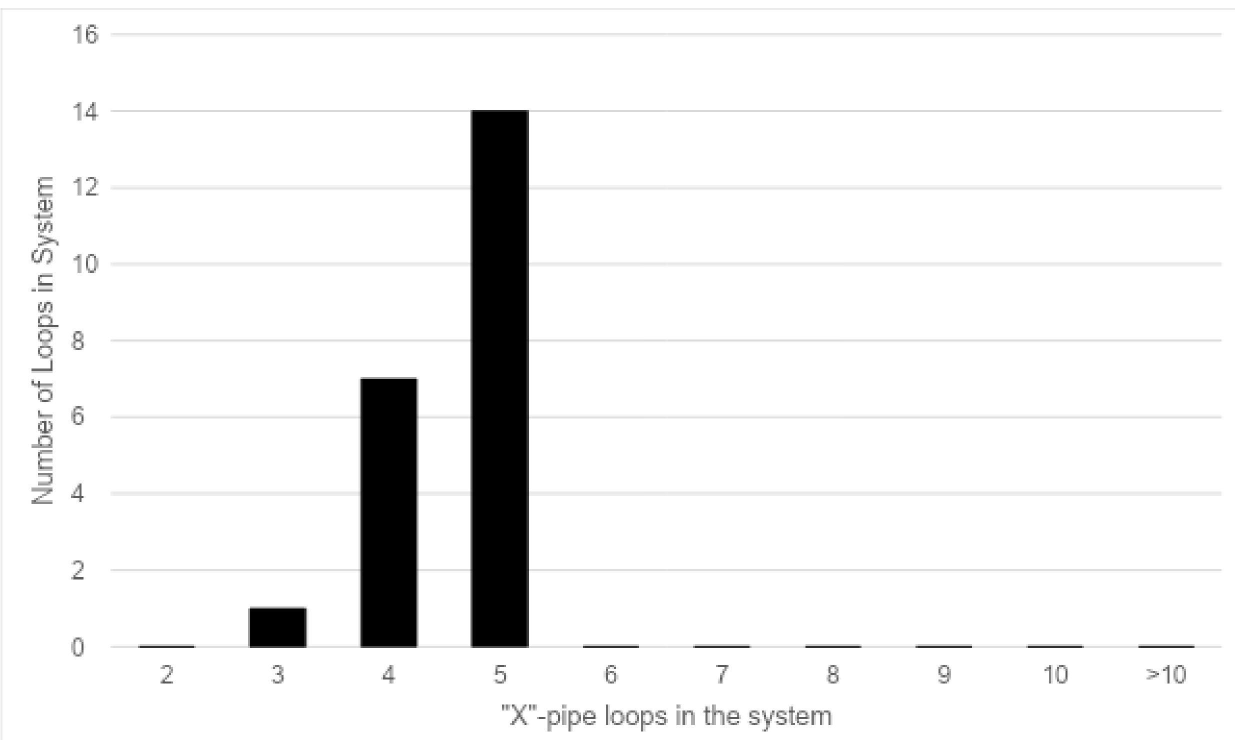
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	No
Background map	No
Elevation data	Yes
Pipe data	Yes
Pipe material	No
Pipe age	No
Pipe pressure class	No
Nominal or actual diameters	Actual
Pump data	NA
Useful horsepower	
Pump operating curves	
Tank data	NA
Elevation 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 Fossolo system is provided below. Using this information, Hoagland et al., classified this system as being a LOOPED system.

# Total Pipes:	58
# Branch Pipes:	1
Ratio (Branch Pipes / Total Pipes):	0.017



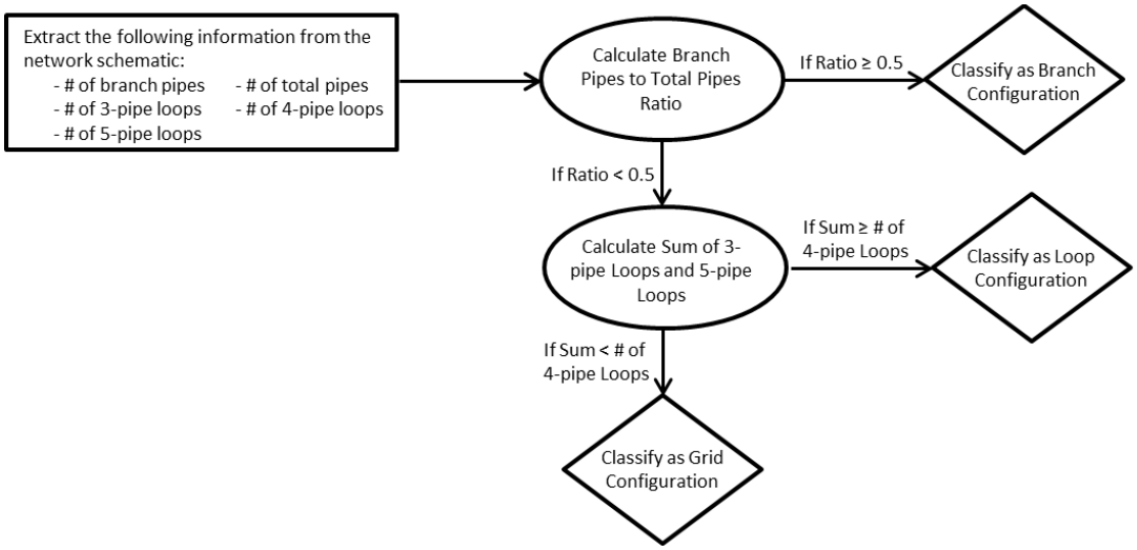


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

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	58
Pipes	58
Nodes	37
Average Diameter	39.2
Reduced Nodes	36
Reduced Edges	57
Branched Edges	1
Branched Index	0.0
Meshed Connectedness	0.3
Reduced Meshed Connectedness	0.33
Link Density	0.1
Average Node Degree	3.1
Hwang & Lansey Classification	Transmission Dense-Loop

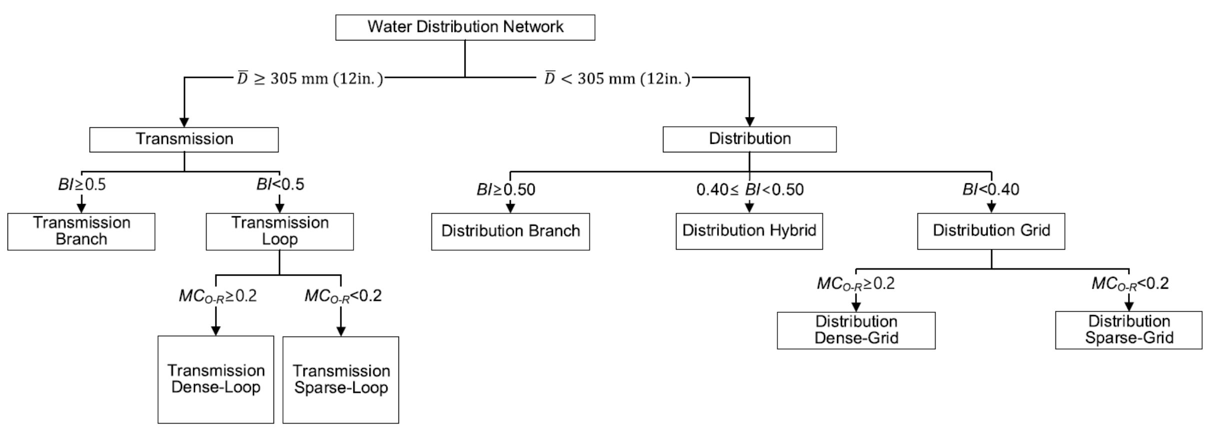


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

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:	58
# Junctions	36
# Reservoirs	1
# Tanks	0
# Regulating Valves	0
# Isolation Values	0
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (mm)	Length (m)
16	3,507
20.4	296
26	630
32.6	1,210
40.8	935
51.4	429
61.4	163
73.6	343
90	355
102.2	133
147.2	147
184	181
204.6	75
229.2	1

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		