Water everywhere!

Understanding & preventing frozen pipe bursts with modern IoT

Olin College of Engineering

SEMTECH

Problem:
Freezing weather can burst pipes.

Water expands in volume when it freezes and puts enormous pressure on its container. This effect can wreak havoc on the plumbing lines that bring water into buildings by causing the pipes to burst. Plumbing infrastructure not well-insulated against cold weather is particularly vulnerable to freezing and bursting, as evidenced by the huge water damage incurred during the 2021 cold snap in Texas.

Opportunity:
Smart infrastructure.

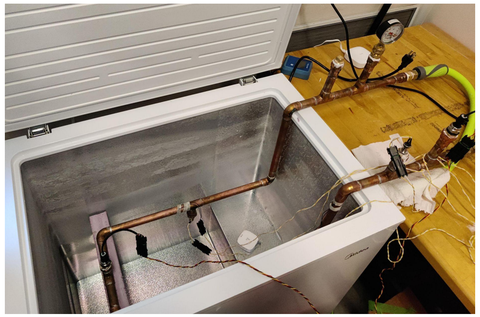
Age-old wisdom suggests that manually dripping water pipes can help prevent bursting, but what if we could remove the human from the loop? Distributed sensors, actuators, and decision-making components could automate this process to ease the burden on humans and improve the resilience of existing plumbing infrastructure. Semtech's LoRa® communications technology provides the low-power connectivity to bring together the components of such a solution.

Goal: Understand how to predict & prevent pipe bursts.

We set out to understand what approach for sensing and action-taking can prevent pipe bursts from happening.

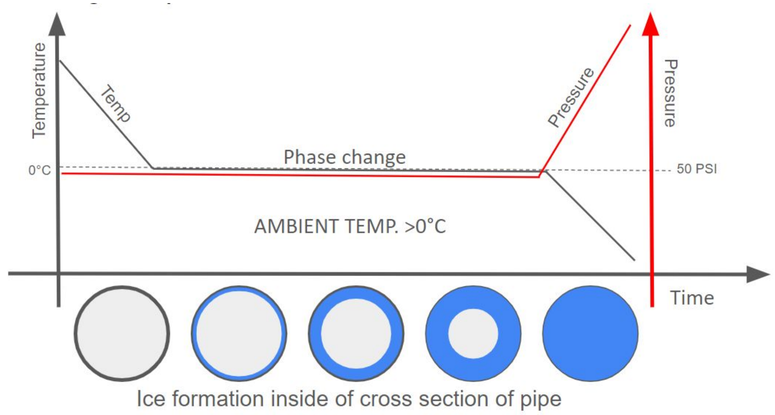
Experimentation:
Sense representative plumbing systems.

We built a copper pipe system pressurized at standard residential plumbing levels to emulate vulnerable pipes in a home setting. Housed in a chest freezer to control the temperature during testing, we measured the temperature and pressure throughout the system to track these metrics during pipe freezing and bursting scenarios.

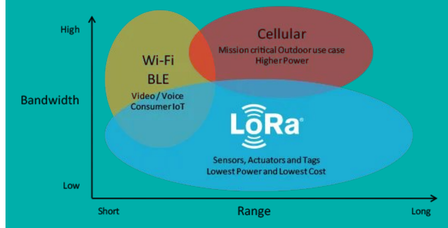


Insights:
Monitor temperature, not pressure.

From freezing our system while monitoring pressure and temperature at different locations showed how ice forms within a pipe. During the phase change of the water the ice formation grows from the walls of the pipe in slowly blocking flow but not changing the pressure till the block is complete. This shows why surface temperature of the pipe is a strong measurement to make decisions to take preventive action based off of.

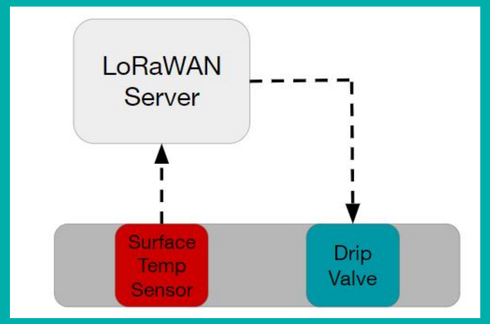


Ice formation inside of cross section of pipe



System Design:
LoRa®.

To explore how to use LoRa and LoRaWAN communication in a sensing solution to prevent pipe bursts, we worked with several different LoRa architectures. We identified an effective system that could integrate our pipe freezing learning into a LoRa based system.



Next Steps:

1. Testing and understanding how our learning from controlled test systems transfer to real home plumbing system. This would involve placing sensors throughout home plumbing systems in houses that are vulnerable to pipe freezing and bursting.
2. More research and experimentation needs to be done to create a model of how drip flow rates affect freezing behaviors.


Aaron Blust


Luke Raus


Jack Levitsky


Andrew Phillips

Advisor: Alessandra Ferzoco

Liaison: Loren Geilen