

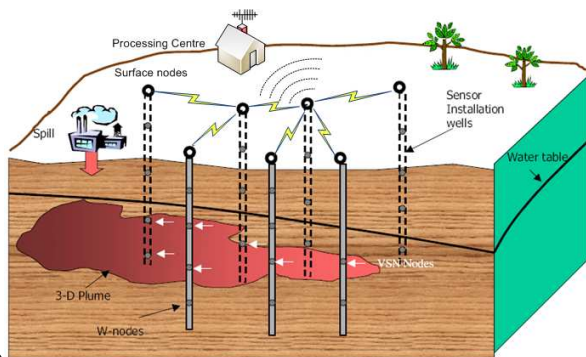
## Abstract

A real-time subsurface chemical plume monitoring and tracking system is being developed that uses wireless-sensor networking to automatically extract data from underground chemical sensors. This system is aimed at tracking plumes caused by the release of toxic chemicals and biological agents into the environment as a result of accidental spills and improper disposal. Current practice involves manual collection of samples from monitoring wells followed by laboratory analysis, an expensive process taking days to weeks; such a delay reduces the effectiveness of mitigation techniques as well. Virtual Sensor Networks (VSN), a novel resource efficient approach for sensor networking being developed to track the migrating underground plumes, will be applicable to a broad class of problems. Laboratory based experiments and simulations are in progress to demonstrate the feasibility of the approach for large-scale plume tracking.

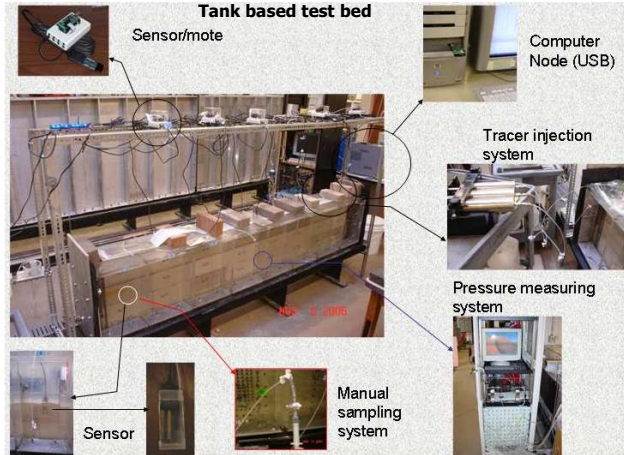
## Motivation

- ❑ Release of toxic chemicals or biological agents into the subsurface often results in chemical plumes
- ❑ The migration of such plumes poses a risk to human and ecological environment
- ❑ Temporal and spatial monitoring of plume concentration is needed to access risk, make decisions, and take remedial actions
- ❑ Wireless sensor networking technology can be exploited to provide the temporal and spatial granularity required
- ❑ Virtual Sensor Network concept that we have developed can
  - ❑ Address new data collection and delivery challenges due to migrating, splitting, and merging plumes
  - ❑ Be used to build new collaborative wireless sensor networking technologies that are applicable for broad class of problems
  - ❑ Resource efficiency, network topology and application independence, ability to span large geographical areas, etc.

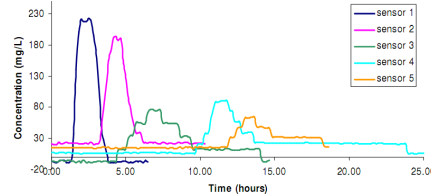
## System Overview



## Underground Chemical Movement Tracking

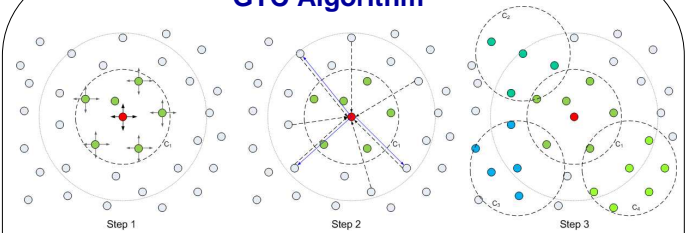


- ❑ Tank was packed with a heterogeneous sand sample
- ❑ Manual and automated sampling at discrete time intervals
- ❑ 10 Decagon ECH<sub>2</sub>O-TE sensors
- ❑ 5 TelosB sensor motes

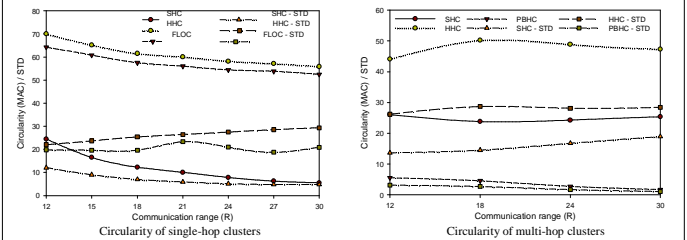


- ❑ Correlation between manual and sensor measurements
- ❑ Breakthrough curves illustrate the movement of tracer in the tank

## GTC Algorithm



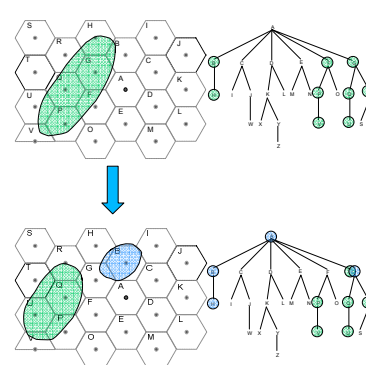
- ❑ GTC - Generic Top-down Cluster and cluster tree formation algorithm
- ❑ Clustering simplifies network management, enable power conservation, and reduce channel contention
- ❑ Cluster tree further enhance upper layer functions such as routing, broadcasting, and query delivery
- ❑ Cluster based organization allows effective communication between sensor groups



- ❑ GTC algorithm is
  - ❑ Highly configurable
  - ❑ Independent of neighborhood information, location awareness, time synchronization, and network topology
  - ❑ Scales well into large networks
- ❑ Algorithm performs better than exiting clustering solutions in providing more circular and larger clusters
- ❑ Having circular clusters increase effectiveness of data gathering and increase lifetime of the sensor network

## Virtual Sensor Networks

- ❑ Enables collaboration among sensor networks deployed within the same geographical area
- ❑ Enables coherence among dynamically varying subset of sensors
- ❑ Enhance performance, scalability, simplified application deployment, resource sharing, security, etc.
- ❑ Applicable to a broad class of problems
  - ❑ Monitoring rock sliding and animal crossing within a mountainous terrain
  - ❑ Enabling privacy in collaborative sensor networks



## Summary and Future Work

- ❑ Laboratory based experiments and simulations demonstrate the feasibility of automated monitoring of underground chemical movements
- ❑ A clustering algorithm (GTC) has been developed that is configurable and capable of effectively spanning a large geographical area
- ❑ Experimental prototype for plume-tracking is being developed using a 3D tank
- ❑ Algorithms and middleware is being developed for Virtual Sensor Networking
- ❑ We seek partners for research collaboration, product development, and commercialization of novel sensor network applications