A Portable Wideband System for Monitoring and Locating Firefighters and Other Emergency Personnel

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Outline

- Motivation
  - Key issues
- Approach
  - System concept
  - Factors influencing design
- Implementation
  - Prime
  - Alternatives
  - Operational issues

Motivation for System

- Save lives
  - Locate incapacitated personnel
  - Direct rescue teams
- Situational awareness
  - Monitor personnel status
  - Personnel deployment
  - Real-time sensor data

Key Issues

- Required parameters
  - Spatial resolution/accuracy
  - Update rate
  - Number of transponder units
- Environmental factors
  - Absorption/scattering
  - Multipath
  - Interference and noise

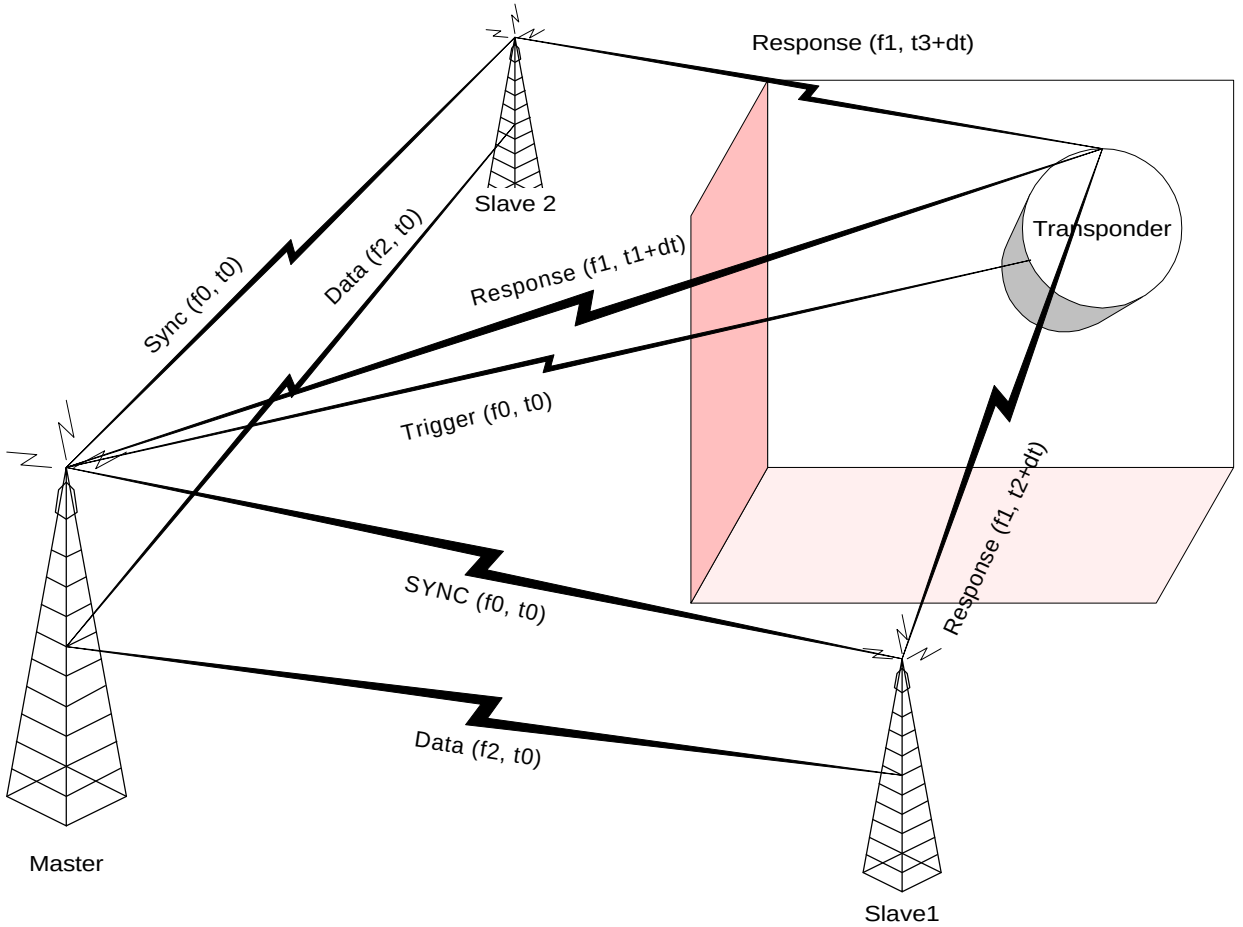
Approach

- Multistatic Time Difference of Arrival
- Frequency Hopping
- Separate Transmit and Receive Frequencies
- Isolating Delay Window for Each ID
- Wide Band Modulation
  - Pseudo random phase modulation
- Separate data link and localization

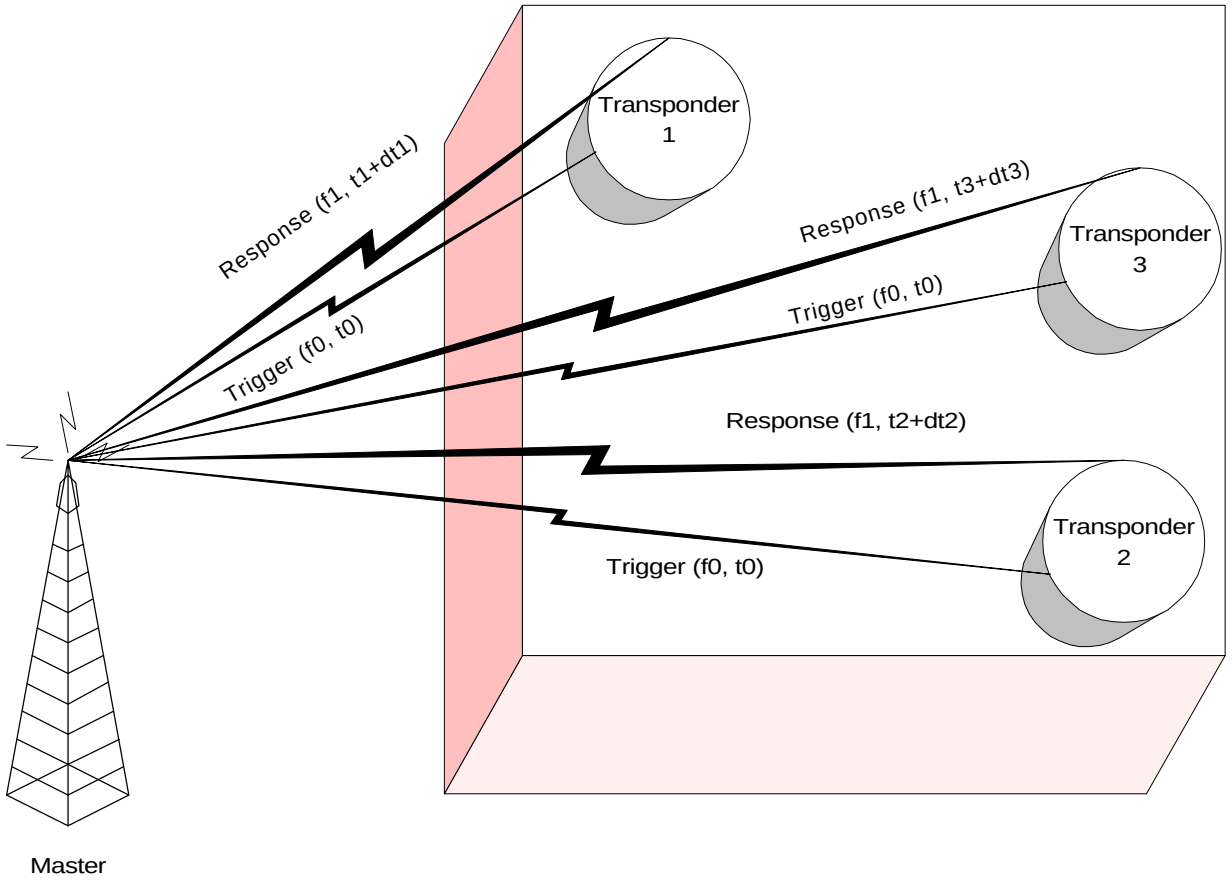
System Concept

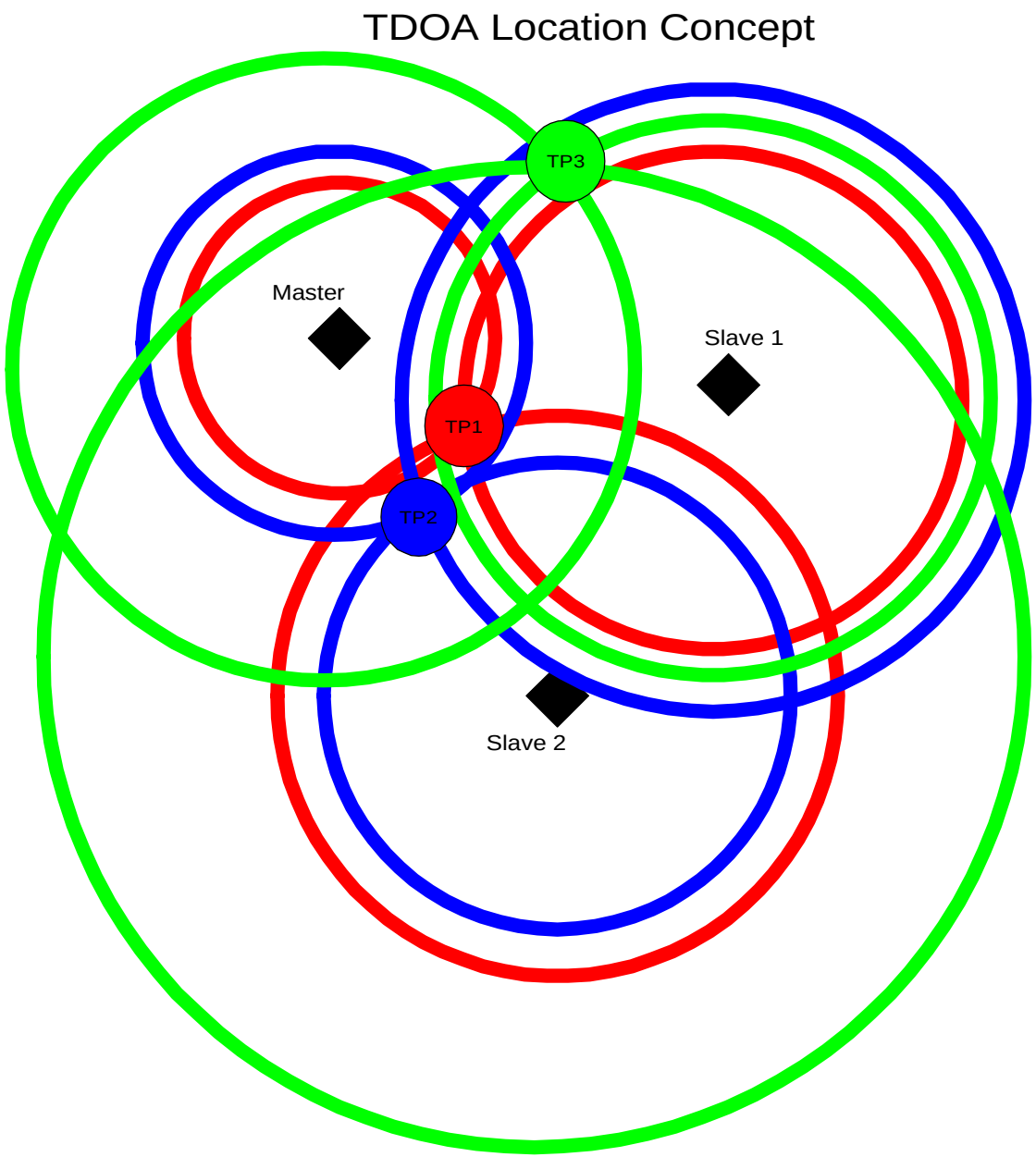
- Command Elements
  - 1 Master Transmit / Receive Station
  - 2 or more Slave Receive Stations
  - Data link
- Portable Transponders
  - Locate the emergency personnel inside the building
  - Unique ID’s
  - Data links to command elements

System Concept



Multi-Transponder System Concept




TDOA Location Concept
TP3
Master
Slave 1
TP1
TP2
Slave 2

Factors Influencing Design

- Required Specifications
- Choice of Frequencies
- Choice of Addressing
- Operational Considerations

Factors Influencing Choice of Freq

- Higher
  - Bandwidth for range resolution
  - Bandwidth for hopping
  - Penetration of structures
  - Interference from other uses
- Lower
  - Cost of components
  - Complexity of design
  - SiGe large scale integration

Implementation

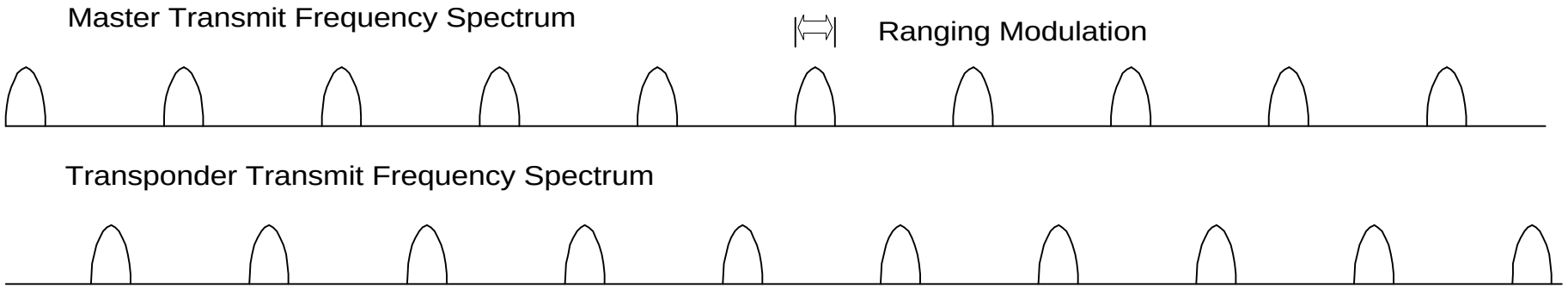
- Prime
  - Modified “Slotted Aloha”
  - System timing
  - Block level design
  - System specs
- Alternatives
  - Poled wideband
  - Ultrawideband

Prime Implementation

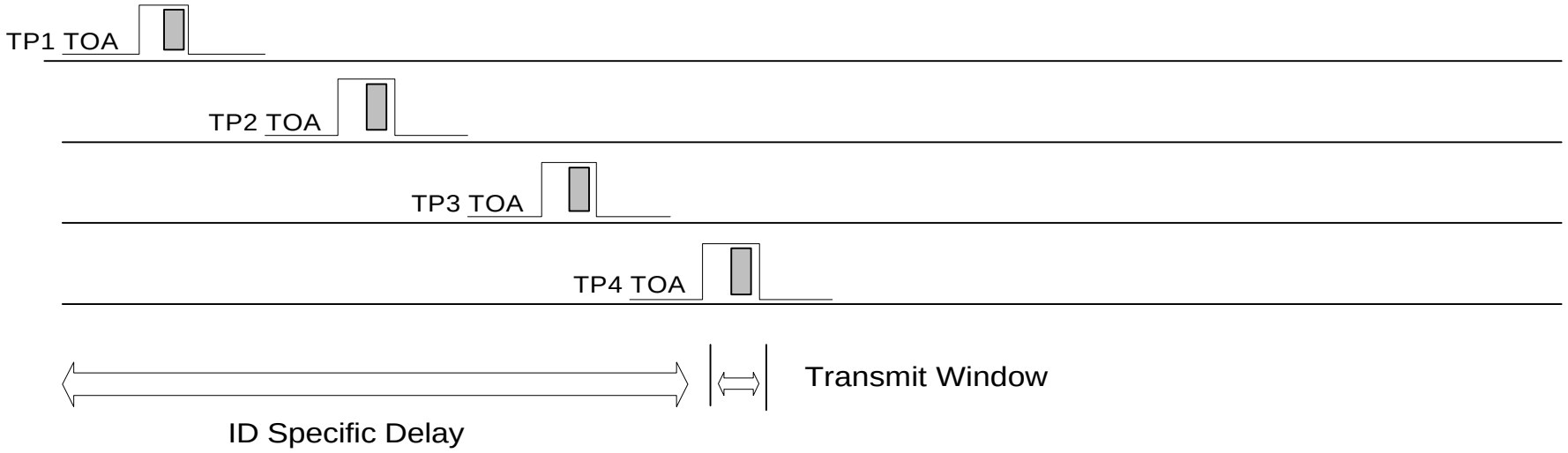
- Two Frequencies
- Master Frequency
  - Pulse sequence for synchronization
  - Received by Slaves and Transponders
- Transponder Reply Frequency
  - Modified Slotted Aloha Timing
- Independent Command Data Link

Frequency and Timing

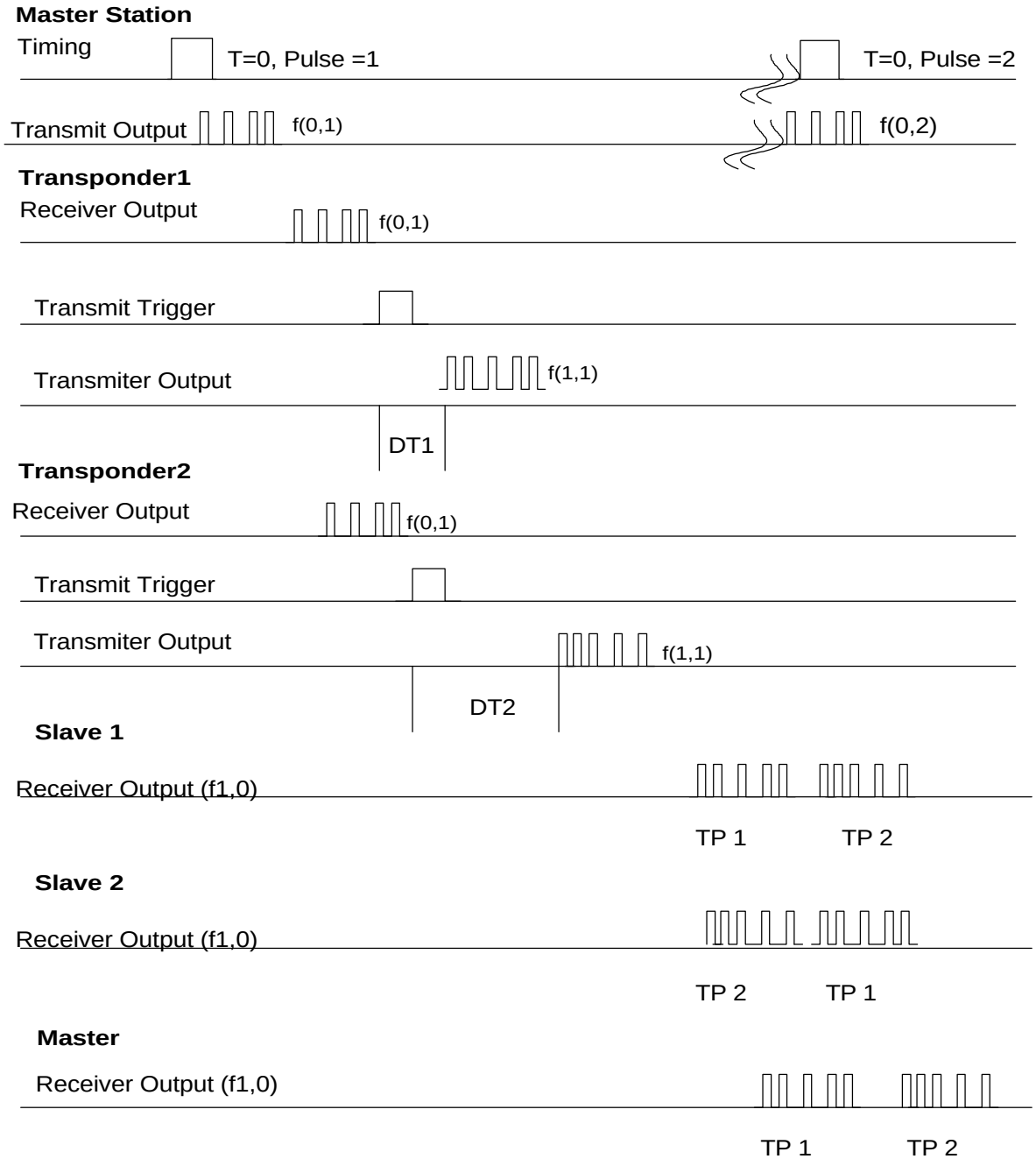
Frequency Hopping Spectrum



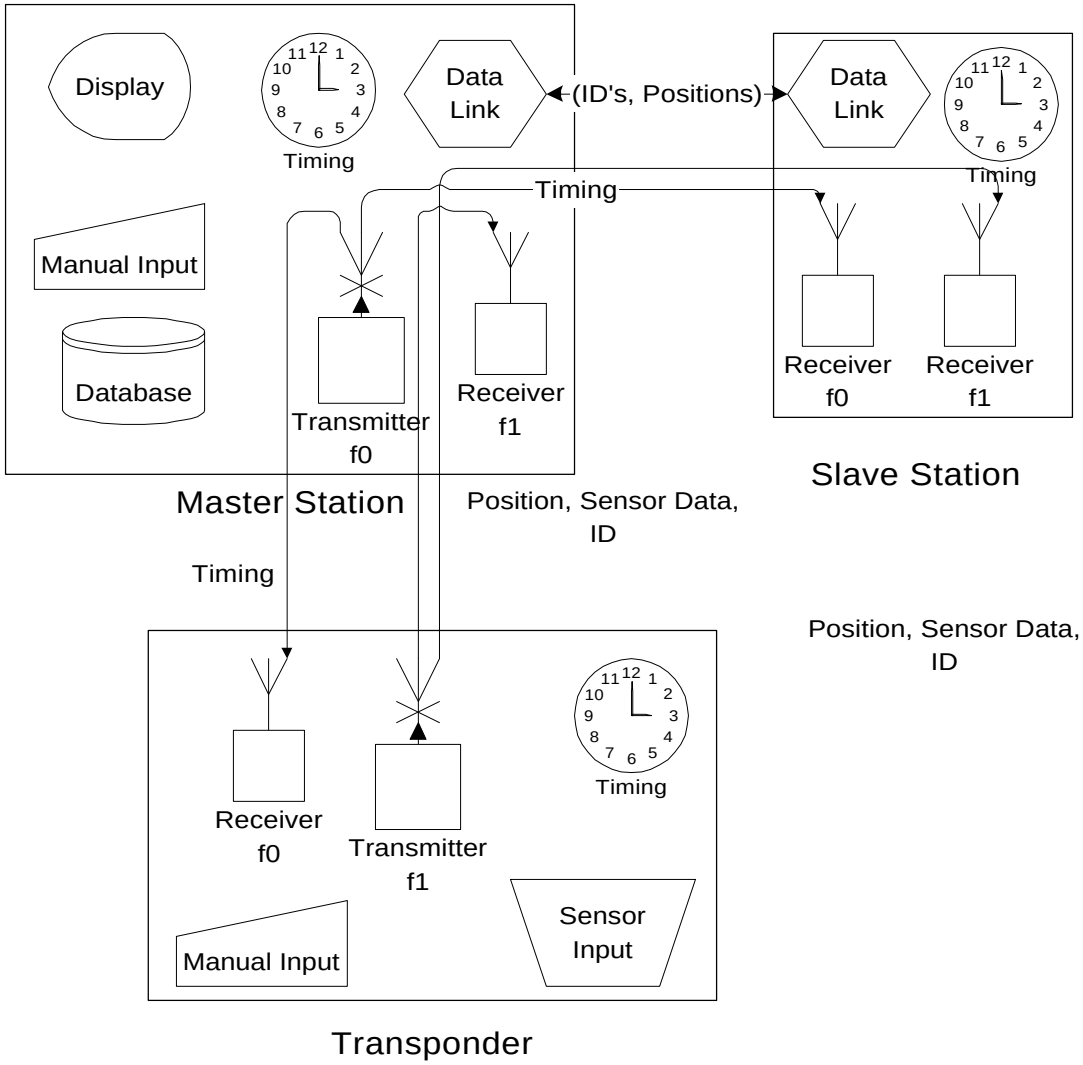
Tine of Arrival with delay (ID)



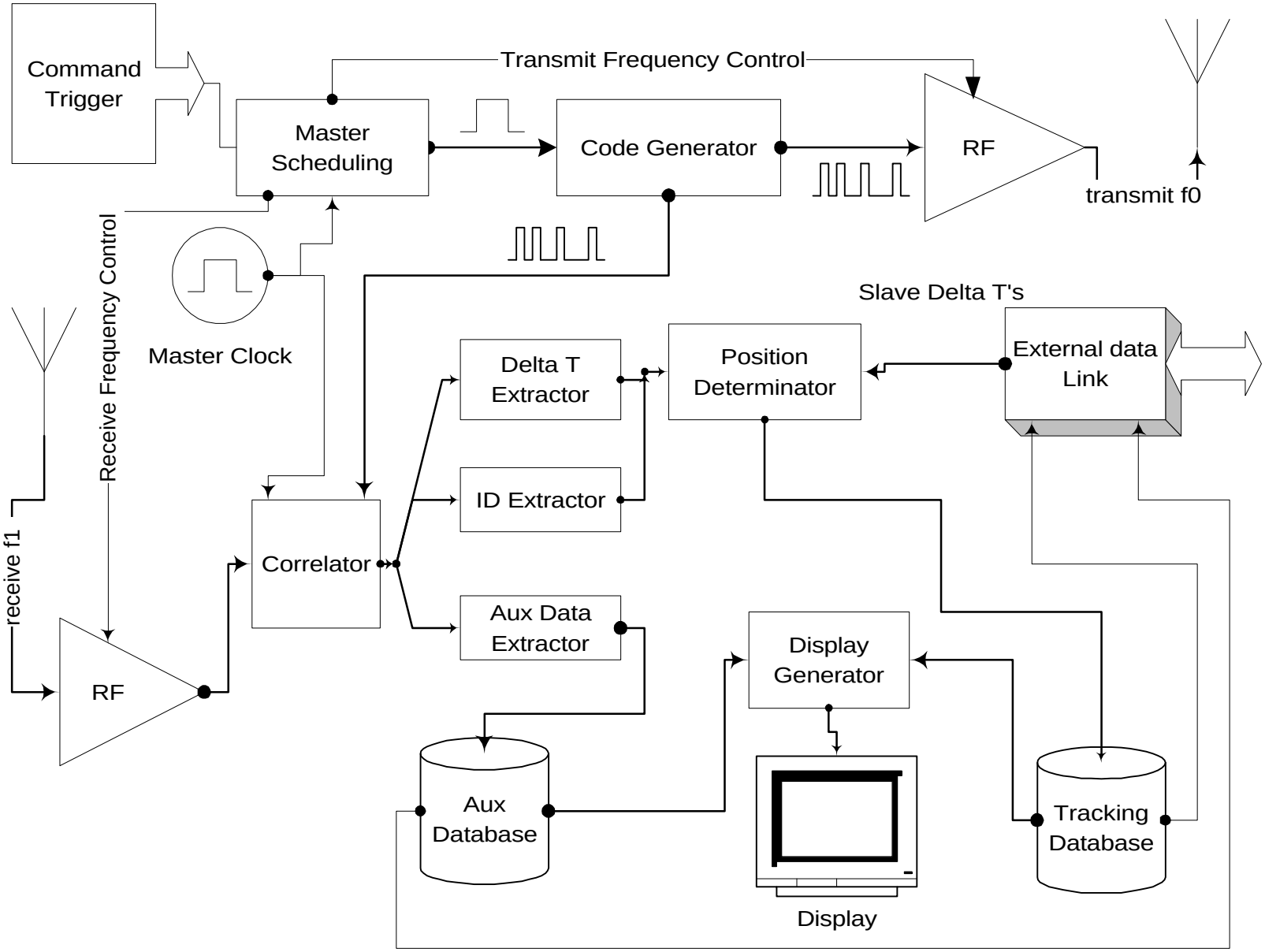
Timing & Frequencies



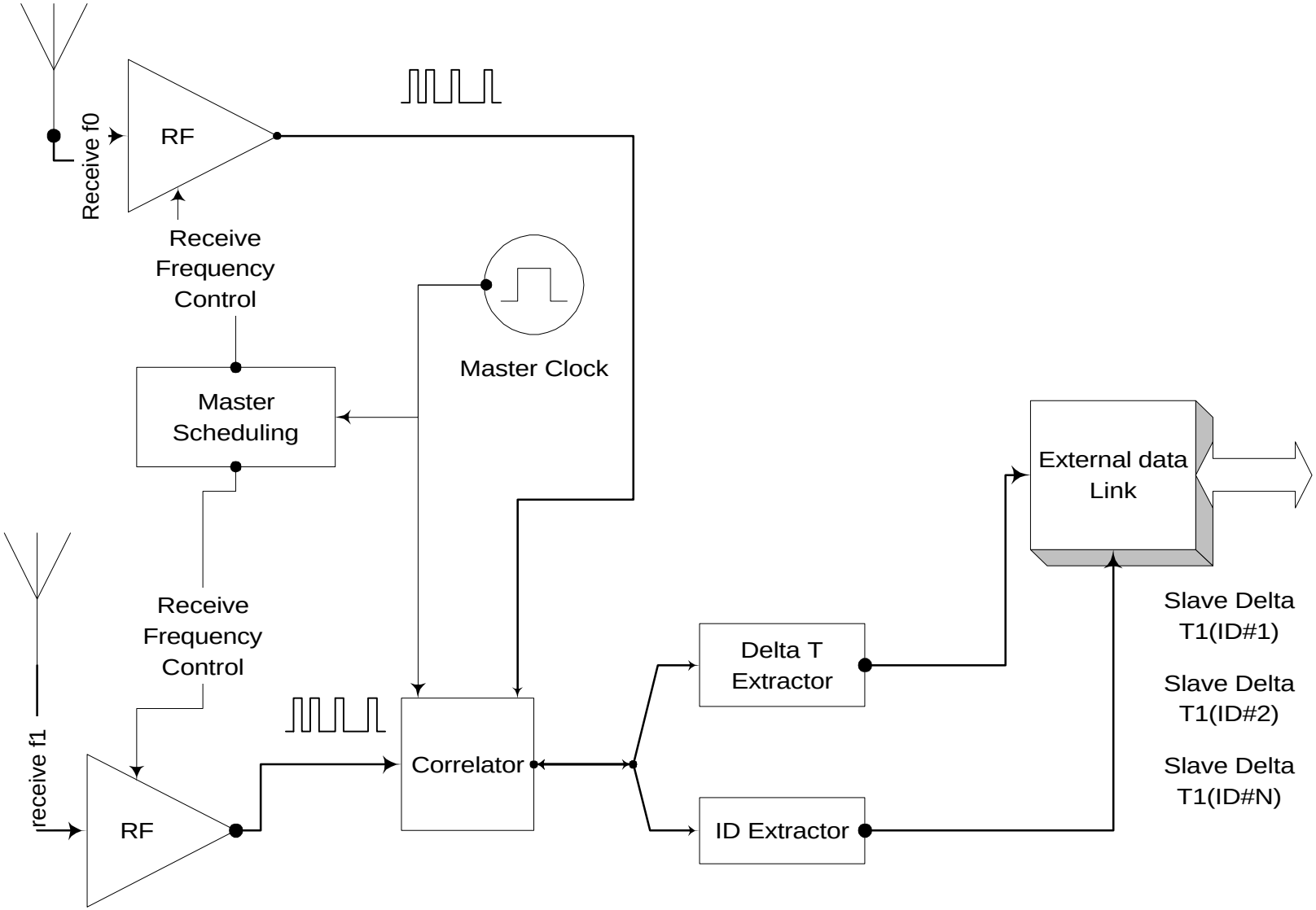
System Block Diagram



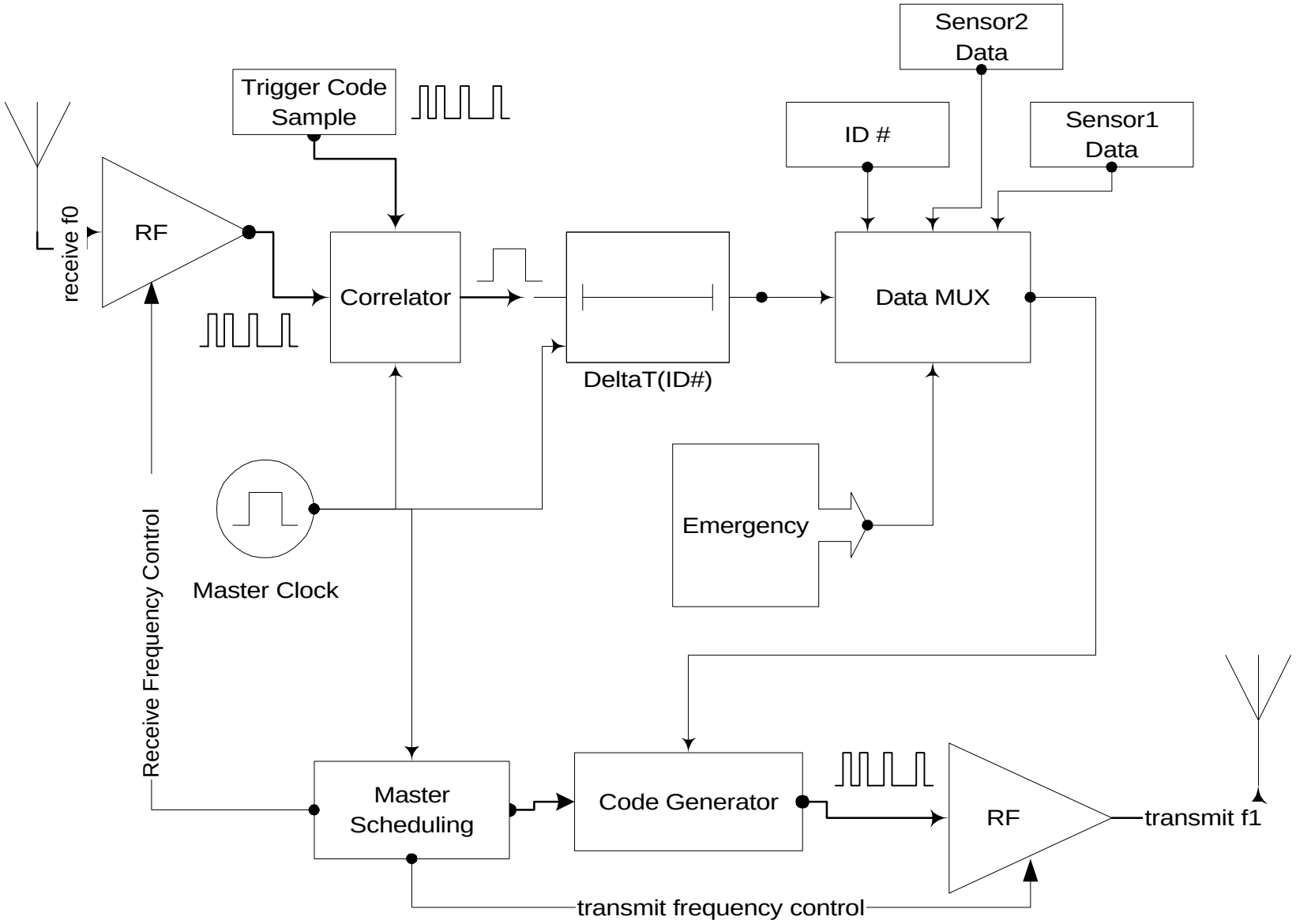
Master Station Blocks



Slave Station Blocks



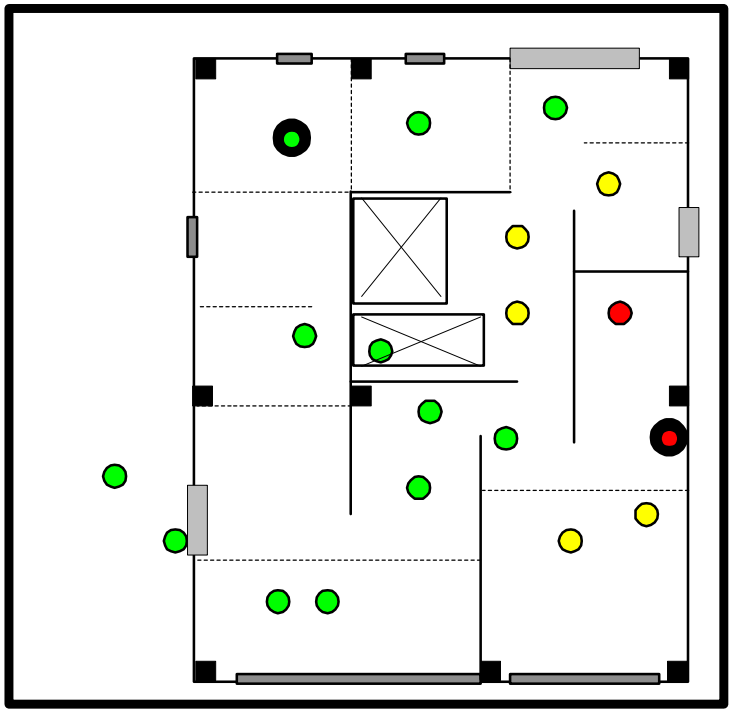
Transponder Blocks



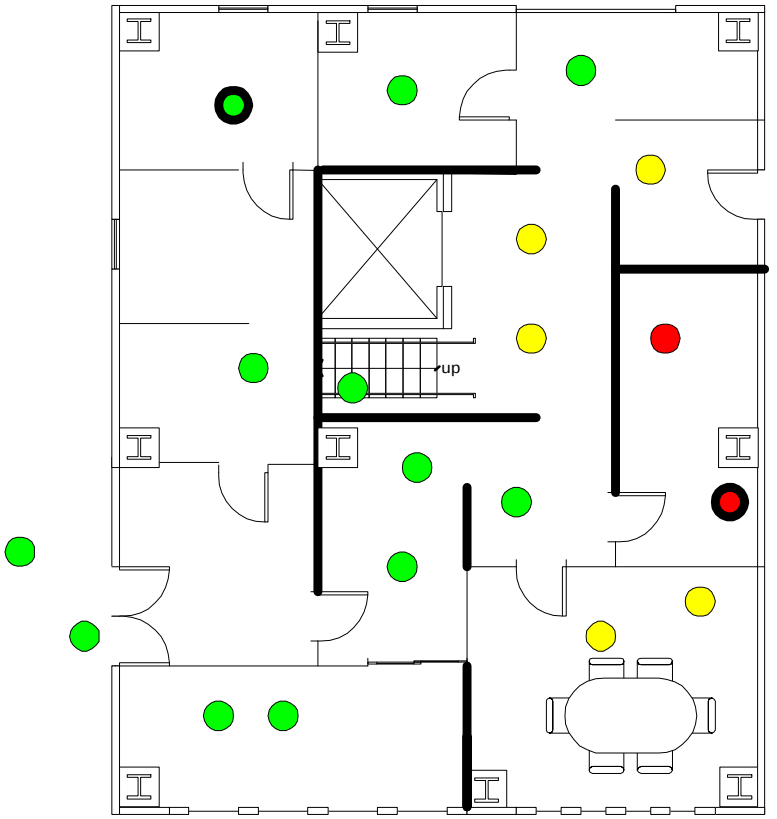
System Specifications

Range Accuracy	1 m
Maximum Range	1 km
Track Update Rate	1 /s
Operating Frequency	5 GHz
Max # of Active Transponders	100

System Application



Master Station Display



Legend

Shaft Window Door

Structure False Wall

Normal Warm Hot

Normal ALARM

Alternative Implementations

- Wideband
  - *Modified Slotted Aloha with extra delays
  - Poled 2 frequency code modulated
- Ultra Wideband
  - Master + Slaves + Transponders
  - Peer-to-Peer Network

Alternatives

- Wideband
  - Poled
    - Simplified addressing scheme
    - Rep rate varies with number of transponders
    - Possibly lower probability of detection on each pulse
- Ultrawideband
  - Better penetration of complex structures
  - possibly simpler deployment
  - Short range
  - Low data rate
  - Undeveloped technology

Operational Issues

- Availability of Building CAD Data
- Reliability of System Under Extreme Conditions
  - Heat
  - Water
  - Shock
- Availability of Operating Frequencies