The Small Satellite Integrated Communication Environment (ICE)

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Patent 8,751,064 B2
• **Problem**
  - How to improve communication with small satellites
  - SMALLSATS are supposed to be inexpensive
    - Building NANOSATs has become affordable
    - Launching your satellite has become affordable
    - Everyone forgets about communication
  - The benefits to many small satellites will be lost with the inability to communicate with them

• **Current Situation**
  - Dedicated dish antennas and corresponding ground site hardware
    - Cost: hardware and operations
    - Access: 1 satellite at a time, maybe 4 to 6 accesses per 24 hours
  - So, how do you handle 10, 100, .... 1000 satellites?

• **Solution**
  - Modify existing cellular network infrastructure to create an Integrated Communication Environment (ICE)
  - Leverage existing cellular phones, modified for space communication
  - Add fixed and upward pointing antennas to select cellular towers
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The solution: How does it work?

- **The Satellite Phone (ICE Box)**
  - Smart phone technology
  - Serves as satellite CPU, an even better comms device

- **The Cell Tower (ICE Dish)**
  - Modify existing cell towers with fixed, upward pointing dishes
  - Location, Location, Location ... Cover the globe
  - 3rd world nations rely on cellular technology to communicate

- **Virtual Ground Site (ICE Tray)**
  - Breaks the ground site paradigm
  - The cellular network becomes the ground site
  - Just call your satellite(s)
    - Text commands - Up
    - Text data/product - Down
    - Stream data?
  - Will leverage data packets (ICE Pacs)
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The Tower Infrastructure

- **Individual Towers**
  - Modified with a fixed upward pointing dish antenna
  - Size is frequency dependent
  - Very low sidelobes, minimize interference
  - Leverages existing tower infrastructure

- **It's all in the numbers**
  - One tower provides limited coverage
  - Many overlapping towers provide global coverage
**Spacing**

- Dependent on the desired footprint
  - Beam width (modeled at 3dB half power beamwidth)
  - Impacts satellite transition time (approx 10-20 seconds)
  - Bound logical ICE Pac size

- Numerical balancing act
  - Link Budget Analysis (frequency, gain, dish size, etc)
  - Frequency also defines provider and cell protocol (service you get)

- Overlap will also ensure handoff to neighboring cell

**For Example**

- Satellite altitude is 300 km (defines the range)
- Assume a 4G Network operating at 4GHz
- Dish must be 25 cm diameter illuminated area, larger dish to minimize interference
- Results in an ~18 degree footprint
- With a 35% overlap, ground spacing should be approximately 60 km
- Resulting in approximately 50K cell tower globally (land cover)
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The Tower Infrastructure (Spacing)

Notional ICE Implementation in Florida
- Single Access
- Double Access
- Triple Access

Notional ICE Dish Antenna Pattern
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The Satellite Phone (ICE Box)

• **Leverage Smartphone technology**
  - Powerful CPU, miniaturized, lightweight
  - Select Network based on anticipated product
    - Defines ICE Pac requirements
  - Bandwidth impacts Link Budget
  - Bandwidth defines products
  - Power is adjustable, not limited by safety

• **Antenna (Helix?)**
  - Designed to Overlap ICE Dish Coverage
    - Ensures continuing coverage
  - Designed to ensure comms
    - Link Budget
• **Operations (ICE Software)**
  - Satellite position is known
    - Status of Health – GPS
  - Cell Towers are known
    - Approved communication list
  - Cell Tower access will dictate continual coverage
    - No need to establish connection, shorten protocol
  - Many satellites can be managed by each tower

• **Data (ICE Pacs and ICE Tray)**
  - Uplink
    - Commands (small messages)
  - Downlink
    - Status of Health
    - Data (Images, Raw Data, Video, etc)
  - Software
    - Manage and reconstruct ICE Pacs
    - Manage tower assignment
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Potential Applications

• “Look at me”
  • Your land device has GPS
  • Application will manage tasks
  • All participating/available satellites are assigned
  • Satellites are tasked based on mission planner
  • ICE ensures fast/timely response

• “The Dynamic Earth”
  • Utilizes available globe tools
    o Google Earth, World wind, CESIUM
  • Participating satellites
    o Image dump mode
    o Stream pics/video to DE server
  • Supports natural disaster tracking
    o Pre/post hurricane, tsunami,
    o Oil Spill tracker
    o etc
ICE offers a new novel approach to satellite communication
  • Leverages existing cellular technology and infrastructure

Offers a shift in the traditional communications paradigm
  • From single-node ground site, to a network of antennas

Scalable (as satellite numbers increase)
  • Each satellite has its own phone number
  • Many satellites can pass through a single node
  • No competition for communication access

ICE is not “Evolutionary”, its “Revolutionary”
  • Puts satellite communication in the hands of the operator
Questions