Developing an Expandable Reconfigurable Instrument Node as a Building Block for a Web Sensor Strand

Goal

Observing physical phenomenon such as soil moisture, ocean water salinity, underground geological parameters etc at high spatial resolution, over a large exploring volume and more importantly at a faster interval is important for understanding Earth eco-systems. Currently, these parameters are observed by air, space, or ground based web of sensors operating in a non-coherent way. The technology that will be developed under this effort will enable scientists to operate the vast web of sensors in coherence with other members of the web. Thus making it possible to observe scientific phenomenon at very high spatial resolution and covering large area in a shortest possible time.

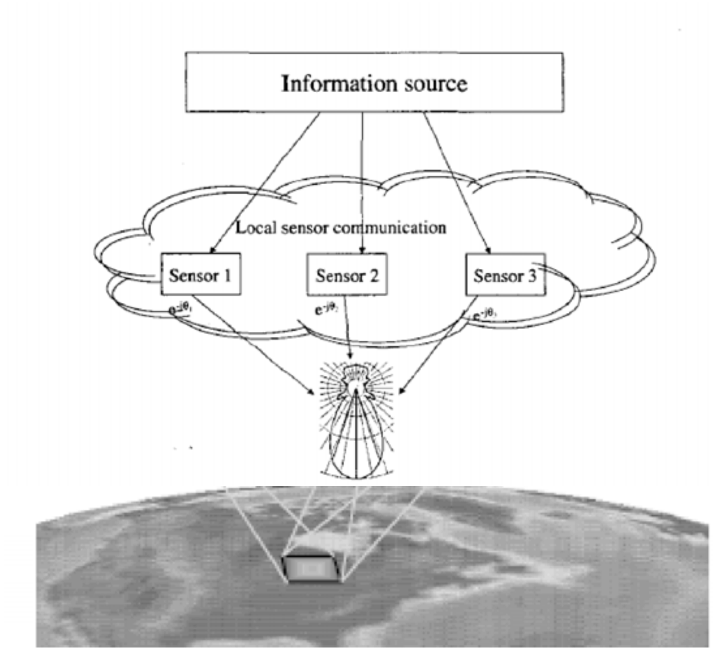


Figure 1

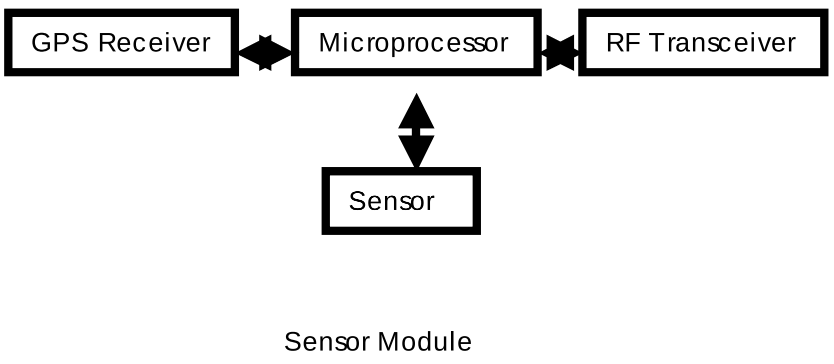


Figure 2

Technical Approach

1. In a web of sensors when suitably weighted signal is transmitted/received through antenna elements it creates microwave beam in a direction of interest. A key requirement to achieve the beam creation in an interested direction is the synchronization of time, frequency and phase of carrier signal.
2. To achieve carrier synchronization we assume:
   (a) Sensors are randomly distributed
   (b) One of the sensors acts as a Master and rest act as slaves
   (c) Master sensors broadcast the carrier and slaves are asked to lock to the master using the NCO and PLL (Figure 3).

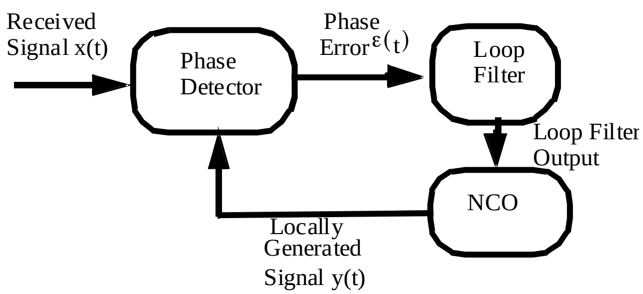


Figure 3

The performance of coherent web of sensors under various phase errors will be estimated under these studies. The communication channels between the sensors may (a) time invariant single path, (b) time varying single path, (c) time varying multi path. The performance of web of sensors will have significant effect on the type of channel assumed in the synchronization.

Comparative Technology Assessment

The space borne radar sensor provides the possibility for continuous imaging of scientific events happening anywhere around the Earth. With the present radar sensor technology there are very important disadvantages.

1. Because large distances are involved, space borne radar sensors require a lot of radiated power and a large antenna size.
2. A large antenna size is also required for high spatial resolution.

One approach to mitigate these shortcomings of a single large sensor is to implement a cluster of sensors (web of sensors), which are very small in weight and size. The web of sensors, when equipped with a coherent transmitter/receiver, can be made to act as very large virtual phased array radar flying in a predetermined/random formation to cover a large area.

Several advantages can be achieved by breaking a single large sensor into a small web of sensors.

1. With the present launching technology, it is much easier to launch small, lightweight sensors compared to one monolithic large, heavy weight sensor.
2. With the application of adaptive array processing, this web of coherent sensors can be used for multi-function electronically.
3. Due to its coherent operation, a sufficiently large signal to noise ratio (SNR) can be achieved through a large effective aperture rather than by increasing the transmit power.
4. Another important advantage of a web of sensors includes graceful performance degradation and ease of replacing a non-working sensor.

Commercial Benefits

The carrier frequency and phase synchronization technology can also be used to develop cooperative communication between two or more transmitters offering the potential for increased power efficiency increasing achievable data rate and range.

1.The technology to be developed to operate multiple spatially distributed sensors in coherence will be first demonstrated for two ground penetrating radars (GPR) located close to the ground at two fixed locations (Figure 4). In such case we will require only a single strand (wireless communication link) between the two radars. In latter stages of this development the locations of these radars will be made dynamic. The successful development of a single strand between two dynamic radars can be extended to multiple sensors. The operational models of such radars that are available at GSFC will be used for demonstration of a single strand concept.

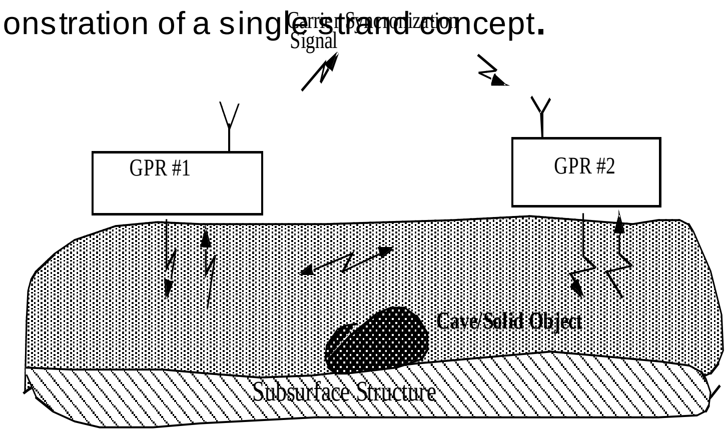
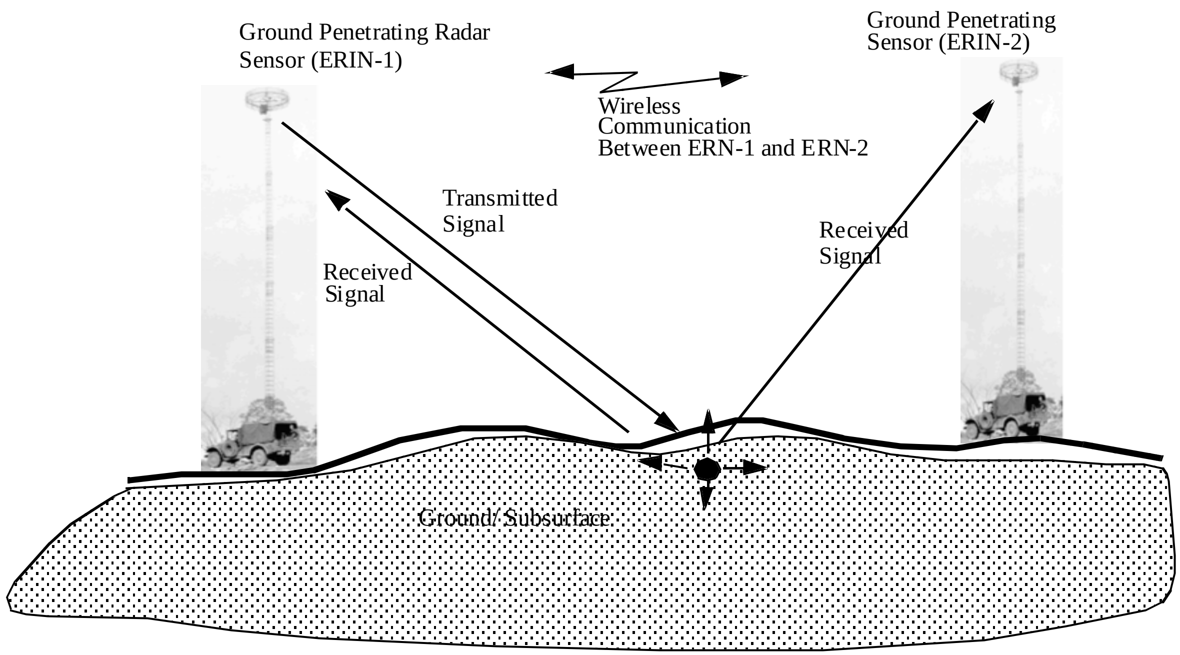


Figure 4

2. One of the essential information required for the carrier synchronization is the exact knowledge of the positions of each sensor. The position of one of the sensors with respect to the other sensor will be known by installing GPS receiver in each sensor. With the present GPS technology, it is possible to locate the positions of sensors within accuracy of couple centimeters. Since the GPR will be operating at frequencies in the range 1-3 GHz (wave length = 30-10 cm), there is uncertainty in the knowledge of the locations of the sensors within fraction of wavelengths.

3. In the process of carrier synchronization, one of the sensors will be designated as master and the other will be slave. The information about the carrier amplitude and phase to which the slave sensors must lock in is broadcast by the master sensor. Using the present state-of –the-art technology for wireless communication, a wireless strand between the two sensors will be established. From the received signal at each slave sensor and using the carrier synchronization circuit depicted in the Figure 3, the phase and signal information broadcasted by the master sensor will be retrieved. The phase of the received signal at the slave sensors will be erroneous due to inaccurate knowledge of the locations. Also the phase of the received signal will depend upon the wireless channel characteristics and the noise generated in the system. The

<u>**New Configurations of Sensor Webs To be Tested**</u>



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