Smart antennas

Smart antennas have been around for about 40 years which were first used in RADAR applications in the form of phased array.

Smart antennas are currently used in wireless communication systems to provide interference reduction and enhanced user capacity, data rates.

A smart antenna is an antenna array system that is aided by a processing system that process the signals received by the array or transmitted by the array using suitable array algorithms to improve wireless system performance.

An antenna array consists of a set of distributed antenna elements (dipoles, monopoles or directional antenna elements) arranged in certain geometry (linear, circular or rectangular grid) where the spacing between the elements can vary.
The signals collected by individual elements are coherently combined in a manner that increases the desired signal strength and reduces the interference from other signals.

The antenna arrays have input or output as RF signals in the analog domain. In the receive mode, the RF signals are converted to digital domain by analog to digital converters (ADCS) and in transmit mode, the baseband digital signals are converted to RF using digital to analog converters (DACS).

The downconversion from RF to baseband or upconversion from baseband to RF can involve the use of IF signals.

The baseband signals received from each antenna is then combined using the "smart" algorithms in a digital processing section. The digital processing section can be implemented on a microprocessor or a DSP OR FPGA. "Smart" algorithm implementation usually is a software code unless implemented in an ASIC OR FPGA.

**Classification of smart antennas**

Based on the signal processing technique, smart antennas can be grouped into four basic types based on
Beamforming (the digital processing has the ability to shape the radiation pattern for both reception and transmission and to adaptively steer beams in the direction of the desired signals and put nulls in the direction of the interfering signals.

Diversity combining (a major limiting factor in wireless communication is multipath fading where the amplitude of received signal fluctuates over time. The occurrence of a deep fade where the signal amplitude becomes very small can impair the communication link for a conventional or signal antenna system. This diversity in the received signal, for the same transmitted information, is exploited by smart antenna processing schemes. Many simple algorithms weight, such as maximal ratio combining, and selection diversity have been developed to take advantage of using antenna arrays to exploit diversity reception in wireless systems.

Space-time equalization (multipath fading in wireless communication can also introduce frequency distortion to received signal. By introducing temporal processing in each antenna element to remove the effect of frequency distortion and doing a
spatial combining described above results in mitigating channel induced frequency selective fading and providing antenna gain. Such schemes are called space–time adaptive processing (STAP) or equalization.

**MULTIPLE INPUT MULTIPLE OUTPUT (MIMO):**

(4) (requires array processing at the transmitter and receiver. There are two different types of MIMO schemes: one uses spatial multiplexing (data is serial to parallel converted and transmitted simultaneously over multiple antenna elements. The receiver also uses multiple antenna elements to receive the signal and applies a maximum likelihood (ML) algorithm to retrieve the simultaneously transmitted symbols and the other uses space time coding using diversity combining techniques to combat fading.

**Advantages**

**Increased number of users**

Due to the targeted nature of smart antennas frequencies can be reused allowing an increased number of users. More users on the same frequency space means that the network provider has lower operating costs in terms of purchasing frequency space.

**Increased Range**
As the smart antenna focuses gain on the communicating device, the range of operation increases. This allows the area serviced by a smart antenna to increase. This can provide a cost saving to network providers as they will not require as many antennas/base stations to provide coverage.

**Geographic Information**

As smart antennas use ‘targeted’ signals the direction in which the antenna is transmitting and the gain required to communicate with a device can be used to determine the location of a device relatively accurately. This allows network providers to offer new services to devices. Some services include, guiding emergency services to your location, location based games and locality information.

**Security**

Smart antennas naturally provide increased security, as the signals are not radiated in all directions as in a traditional omni-directional antenna. This means that if someone wished to intercept transmissions they would need to be at the same location or between the two communicating devices.

**Reduced Interference**

Interference which is usually caused by transmissions which radiate in all directions are less likely to occur due to the directionality introduced by the smart antenna. This aids both the ability to reuse frequencies and achieve greater range.

**Increased bandwidth**
The bandwidth available increases from the reuse of frequencies and also in adaptive arrays as they can utilize the many paths which a signal may follow to reach a device.

**Easily integrated**

Smart antennas are not a new protocol or standard so the antennas can be easily implemented with existing non smart antennas and devices.

**Disadvantages**

**Complex**

A disadvantage of smart antennas is that they are far more complicated than traditional antennas. This means that faults or problems may be harder to diagnose and more likely to occur.

**More Expensive**

As smart antennas are extremely complex, utilizing the latest in processing technology they are far more expensive than traditional antennas. However this cost must be weighed against the cost of frequency space.

**Larger Size**

Due to the antenna arrays which are utilized by smart antenna systems, they are much larger in size than traditional systems. This can be a problem in a social context as antennas can be seen as ugly or unsightly.

**Location**
The location of smart antennas needs to be considered for optimal operation. Due to the directional beam that ‘swings’ from a smart antenna locations which are optimal for a traditional antenna are not for a smart antenna. For example in a road context, smart antennas are better situated away from the road, unlike normal antennas which are best situated along the road.