

# Antenna systems for next 50 years

Kentaro Nishimori

Faculty of Engineering, Niigata University,  
Ikarashi 2-nocho 8050, Nishi-ku Niigata, 950-2181 Japan

**Abstract** – In this paper, when considering wireless communication systems, future outlook regarding signal processing antennas such as adaptive array and MIMO system in next 50 years is discussed. At present, signal processing antennas have been incorporated as MIMO system into the commercial systems such as Wi-Fi and LTE and one of key technologies in broadband wireless communication systems. On the other hand, although the concept of adaptive array has been proposed in 1950s, adaptive array has not been developed as the commercial product in mobile communication systems. In this paper, the history on the research progress and development regarding adaptive antennas and MIMO system is surveyed. Next, developed technologies have been much attracted attention again for massive MIMO in next wireless communication system such as 5G system, and future prospect for next signal processing antennas is described.

**Index Terms** — adaptive antenna, MIMO, Massive MIMO, analog control, digital signal processing, origin regression Introduction

## 1. Introduction

Multiple-input multiple-output (MIMO) and multi-user MIMO (MU-MIMO) systems have been much attention as improving the transmission rate by popularity on smart phone and Wi-Fi [1]. Recently, the concept of massive MIMO has been proposed, because massive MIMO enables simple signal processing in MU-MIMO transmission [2]. These techniques are categorized as signal processing antennas in the field of *Antennas & Propagation society*.

This paper firstly discusses the trends of signal processing antennas in the past and present. Next, future outlook on next signal processing antennas when considering next 50 years is described. From present technologies and future prospect, it is shown that developed technologies which were proposed until 1980s can be re-utilized according the development of each generation: origin regression arises for each generation.

## 2. Past and present on signal processing antennas

A basic technique was developed in 1950s to 1980s and retro directive array antenna is first signal processing antenna in my knowledge [3]. Then, sidelobe canceller was proposed by Howell and minimum mean square error (MMSE) adaptive array was proposed by Widrow [3].

Fig. 1 shows the configuration of analog beam forming (ABF) and this configuration basically used in 1950s and 1980s. However, it is very difficult to realize

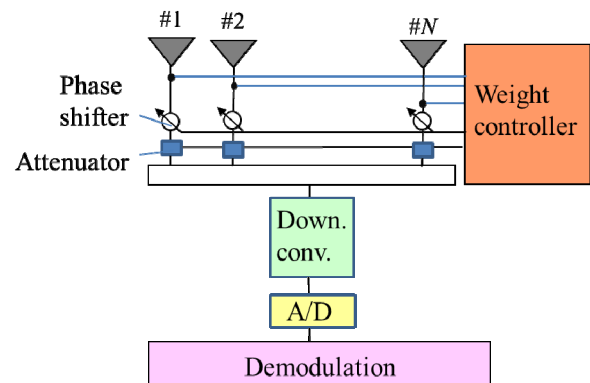


Fig. 1 Configuration by analog beam forming (ABF).

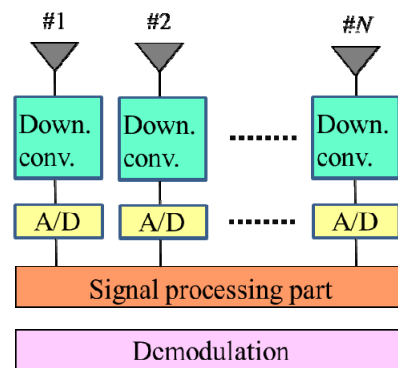


Fig. 2 Configuration of digital beam forming (DBF).

flexible weight control when using ABF and the cost was very expensive and main target of signal processing antennas is not communication but radar system [3].

In 1990s, mobile communication became very popular and Wireless LAN with IEEE802.11a standard using broadband orthogonal frequency division multiplexing (OFDM) was developed in 1999. Digital beam forming (DBF) antennas have been developed in 1990s in Fig. 2 and flexible weight control like computer enables complex signal processing. In 2000s, signal processing antennas was greatly focused on. MIMO system was leading role in wireless communication systems, because there is a very simple merit in MIMO system:  $N$ -transmit and receive antennas can improve  $N$  times frequency utilization [1].

In small cells with fifth generation mobile communication system (5G), massive MIMO has been much attracted much attention. One of configurations of massive MIMO is shown in Fig. 3 [4]. In massive MIMO, analog digital hybrid processing is basically used because power consumption is very high when using DBF [2].

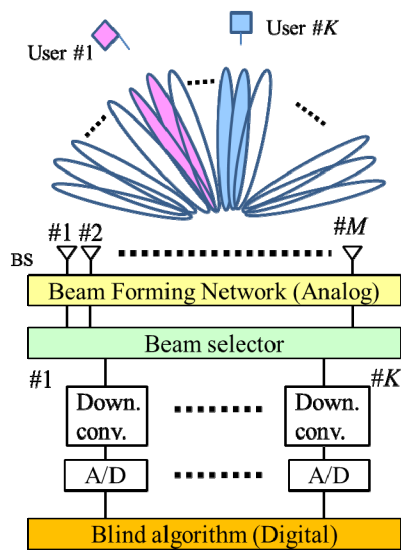


Fig. 3 Configuration of multi-beam massive MIMO.

### 3. Future outlook on signal processing antennas

Fig. 4 shows history and future outlook on signal processing antennas. As can be seen in Fig. 4, original technologies which were proposed until 1980s can be re-utilized according to the development of each generation. This is regarded *origin regression*. In the future, full digital signal processing will be realized. Although it is difficult to prospect the future on signal processing antennas, the future

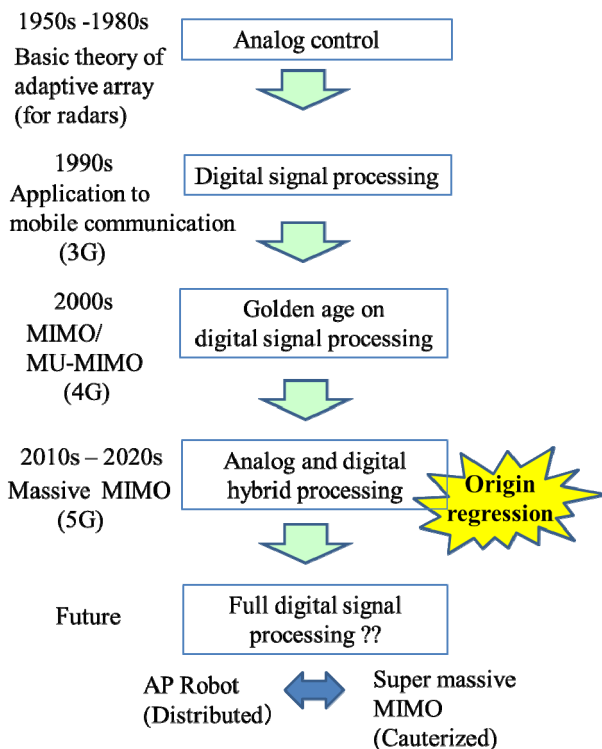


Fig. 4 History and future outlook on signal processing antennas.

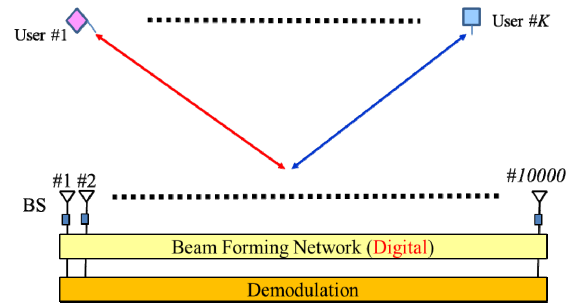


Fig. 5 Super massive MIMO using full DBF.

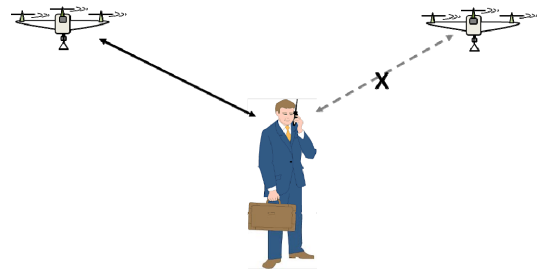


Fig. 6 Concept of AP robot

techniques by author's idea are shown as follows:

- (1) Super massive MIMO with DBF configuration
- (2) AP Robot
- (3) Antennas using surrounding buildings
- (4) Full Duplex
- (5) Ultimate blind algorithm or fast CSI estimation

Each detail is shown in the presentation. Figs. 5 and 6 show configuration of super massive MIMO with DBF configuration and AP Robot, respectively.

When hardware devices became very cheap by the development of new devices, super massive MIMO system in Fig. 6 which realizes *pencil beam* toward each user can be realized: any signal processing is not required. On the other hand, it is expected in the future that access point (AP) works as robot for each person, because unmanned aerial vehicle will be popular in near future.

### 4. Conclusion

In this paper, when considering wireless communication systems, future outlook regarding signal processing antennas such as adaptive array and MIMO system in next 50 years is discussed.

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