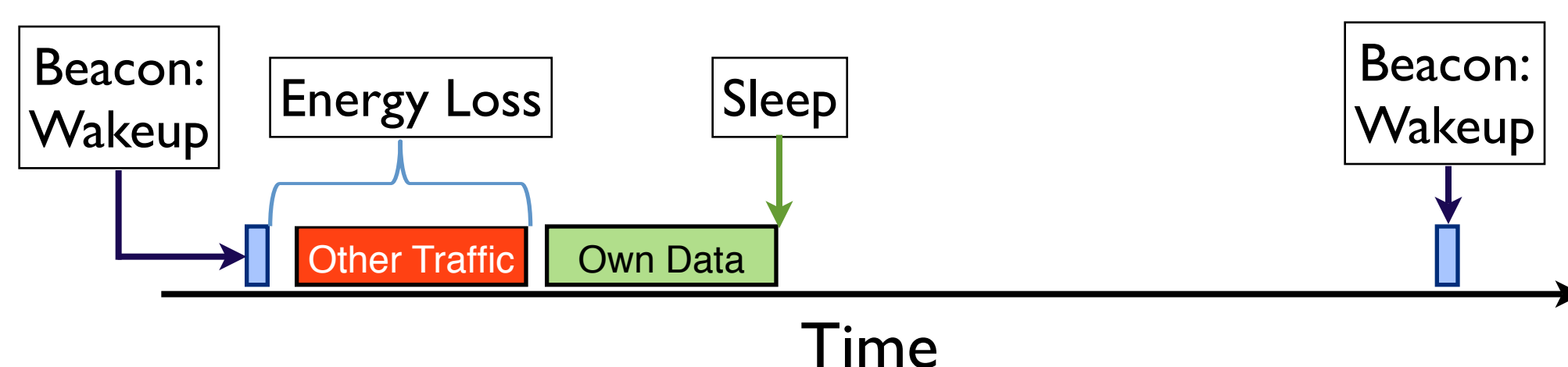


Energy Management for Mobile Devices

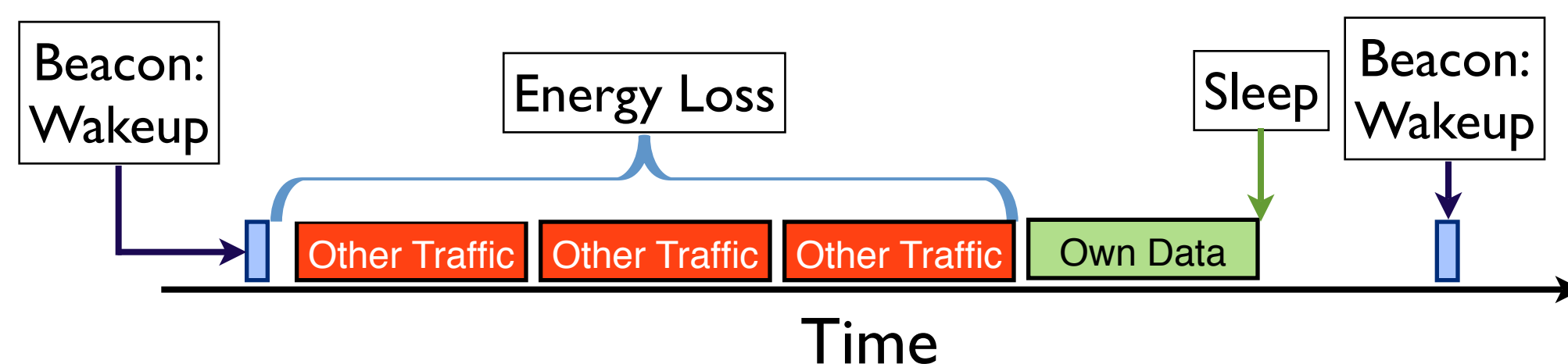
- Significant WiFi energy consumption :
 - Base energy: 155mW, WiFi Rx energy: 350mW
 - WiFi Radio needs to be awake for correct reception

Current Solution Approach: 802.11 PSM

- WiFi radio wakes up every beacon to check for packet
 - Stays awake if beacon specifies packet
 - Continues receiving packets from contending traffic
 - Until it receives its own packets



- Under high contention, WiFi radio stays awake longer
 - Causing significant energy drain



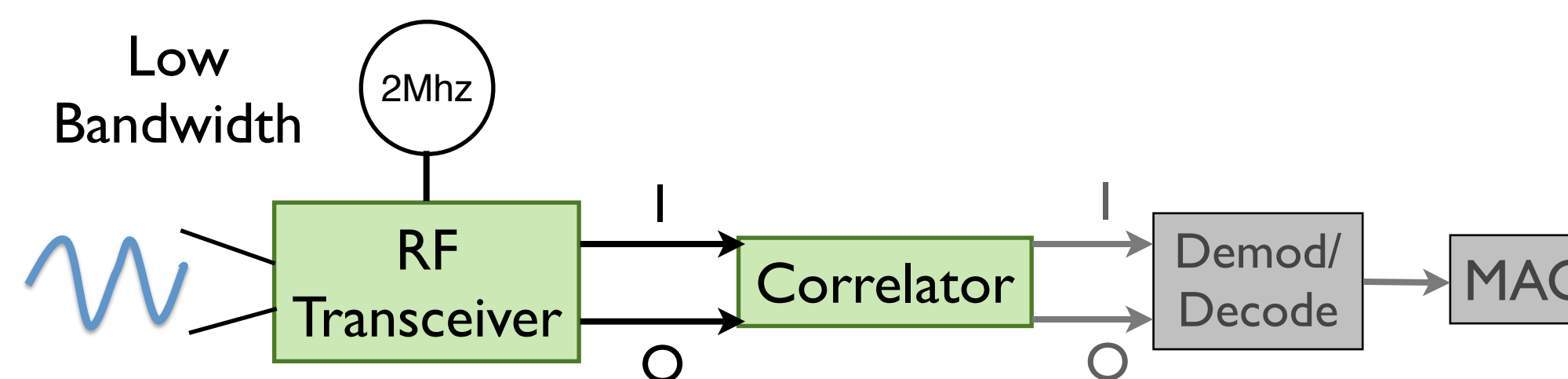
Ideal Solution: Client wakes up instantly **but** only for its own packet

Main Idea: Correlation

- Correlation can be used to send binary information from AP
- AP can signal client to wake up, client uses correlation
- Correlation is robust even in low power, low bandwidth mode

Low Energy Architecture

- WiFi radio will have a special low power mode called:
 - Correlation Mode: Performs correlation at low bandwidth



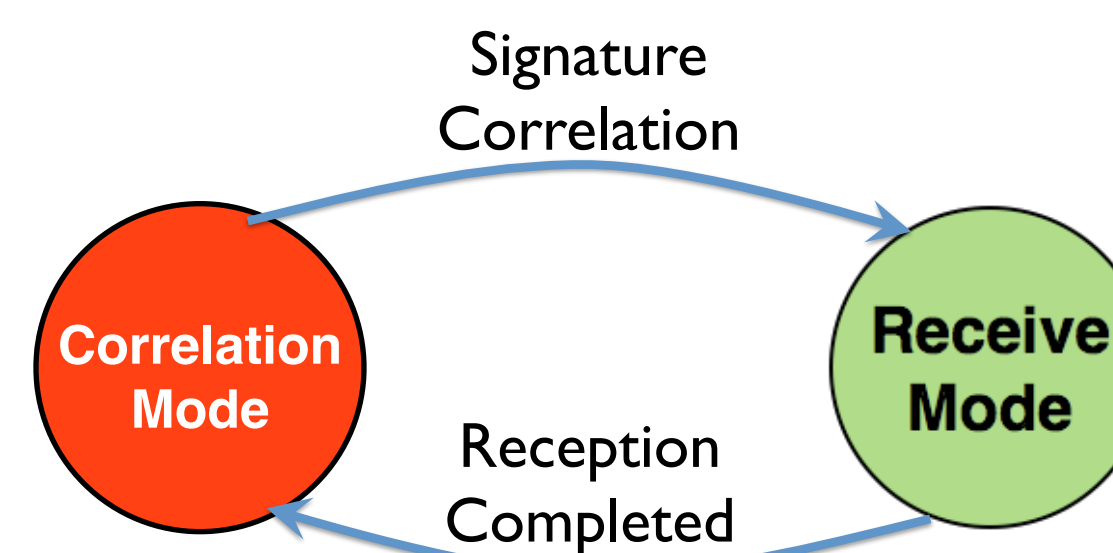
Correlation Mode: Demodulator, Decoder and MAC can be turned off. Transceiver at low bandwidth, Power ~40 mW

Protocol Design

- Each mobile client has a fixed signature
- AP appends client's signature before every packet



- In general, client is in Correlation Mode
 - Searches for its signature using correlation
 - Correlation spikes \Rightarrow Packet for itself from AP
 - Switch to Receive Mode to receive packet

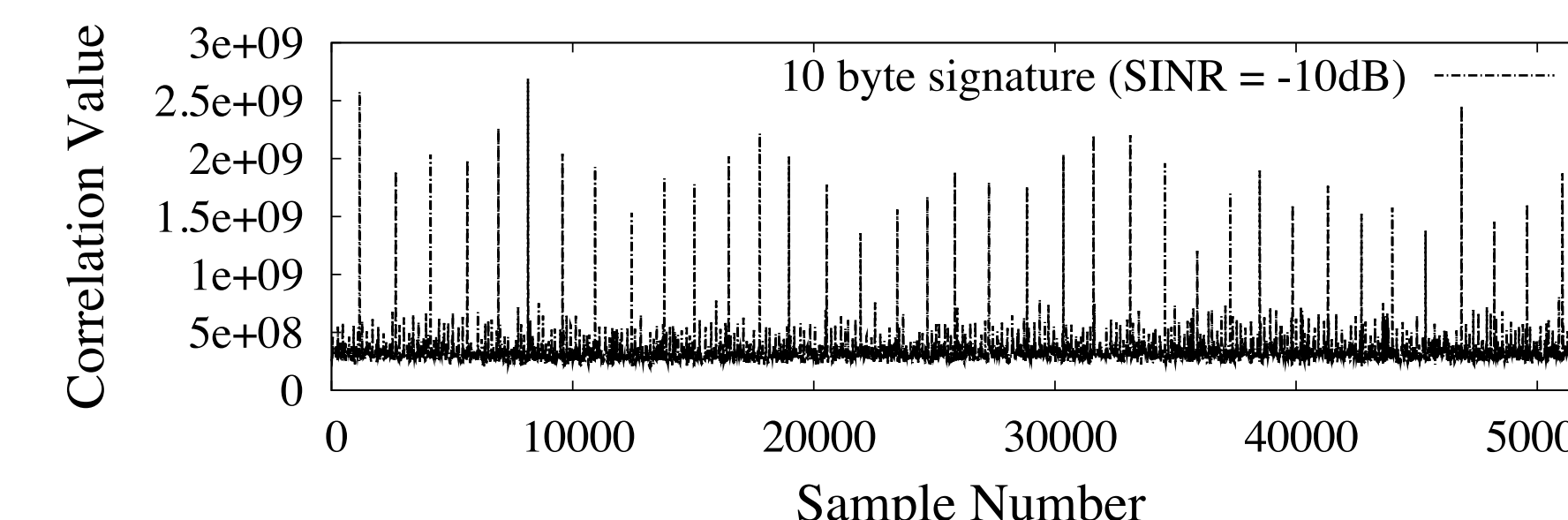


- Even under high contention, WiFi radio is awake in Receive Mode ONLY during its own packet

Correlation enables the client to sleep in presence of high contending traffic

Is Signature Correlation Sufficient?

- Correlation is enough to send a single bit information



- With a low bandwidth of 2Mhz, correlation takes 80us
- Higher bandwidth \Rightarrow faster correlation
 - But higher energy consumption in Correlation Mode
- How different should client signatures be?
 - Experiments show 6 out of a 20 byte signature is enough

Hamming Distance (bits)	16	32	48	64	80
False Positive	0.17	0.0992	0.028	0.022	0.016

Challenges and Opportunites

- Correlation Mode energy can be high?
 - Combine with PSM, Correlation Mode if AP indicates packet
- Turnaround time can be high?
 - Changing clock frequency takes 1ms, use separate clock
 - All other circuitry can be turned off/on within 100us
 - Piggyback signature to combat high turnaround time
 - Use a separate Zigbee like component for correlation

Ongoing Work

- Testbed implementation in progress
- Designing signatures for quicker correlation
- Investigate MAC optimizations for more energy benefits