1. Motivation and Broader Impacts

**Vision**
Self-aware substrates with embedded sensors that can self-power, sense, compute and self-organize their communications.

**Analysis and Maintenance**
Continuous monitoring of structural health with minimal maintenance and configuration costs.

**Impact**
Substrate – as continuous source of energy and communication medium.

**Rationale**
Concept of Smart Substrate Plate (SSP) – a modular platform with integrated sensing nodes.

**Outcome**
Smart Substrate

2. Intellectual Merits

**Uniqueness**
Modular architecture where SSP can be assembled without need for additional instrumentation or wiring.

**Robustness**
Communication through substrate makes the architecture robust to RF jamming or denial or service attacks. More energy efficient in specific cases.

3. Results and Milestones

**Results 1:** Pulse based Ultrasound Networking – Using Pulse-interval encoding (PIE) for transmitting and routing information through the substrate [1].

**Results 2:** Custom substrate computing and communications processor [3].
- Each sensor node harvests its operational energy from ambient vibrations in the substrate.
- When sufficient energy is harvested, the measurement module wakes up determine the failure state in its local environment.
- If a salient event is detected, the transmitter module is activated, which continuously transmits the local ID.
- When a node receives a PIE packet from its neighboring node, it retransmits the packet. The process is repeated till the sink receives the event.
- The sink then examines the source of the event, filters out false-alarms and localizes the substrate area to be examined.
- The proposed approach is scalable and can be applied to different types of substrates including biological substrates.
- Demonstrated different multi-access PIE ultrasound telemetry that is compatible with standard B-scan and M-scan ultrasound imaging protocols.

**Results 3:** In-vivo substrate communications [2].


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