IMD Shield: Securing Implantable Medical Devices

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Medtronic Virtuoso DDE-DDDR implantable cardioverter/defibrillator. Photo courtesy of Medtronic, Inc.

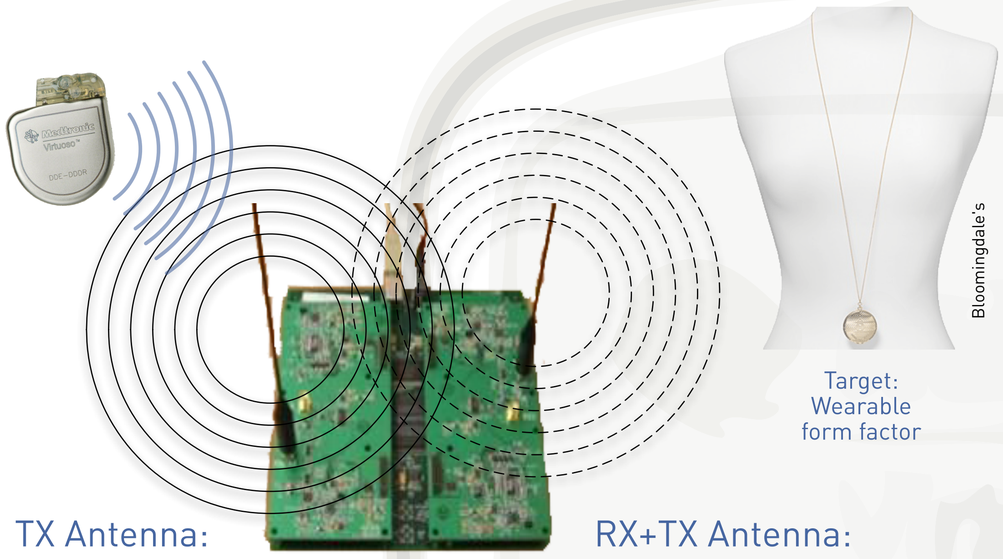
How can we protect a wireless device we cannot modify?

Wireless communication in **implantable medical devices (IMDs)** improves quality of care, but imports security and privacy risks [Oakland 2008]. Millions of IMDs are implanted in patients and **cannot be upgraded.** Can we protect them from known wireless attacks?

The IMD Shield

A **companion device** that protects an **unmodified** IMD from known attacks: **passive eavesdropping** and **active unauthorized commands**.

Key idea: friendly jamming, applied judiciously.



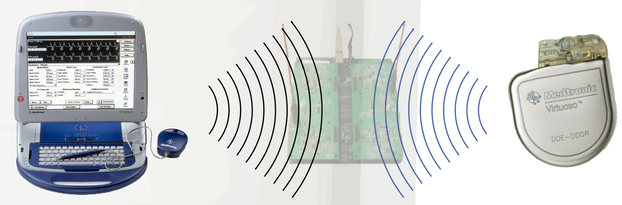
Before IMD Shield: A passive eavesdropper could intercept and decode IMD transmissions.
After: IMD Shield's random jamming during IMD transmissions reduces an adversary to guessing.

Before IMD Shield: An active attacker could successfully issue unauthorized commands to an IMD.
After: IMD Shield's random jamming during programmer transmissions prevents the IMD from ever hearing the command.

Encryption on the Air

The IMD Shield's random jamming signal works like a **one-time pad**; it **does not store secrets.** Jamming results in additive noise that overwhelms the IMD's private signal. Only the IMD Shield **knows the random jamming signal** and can subtract it from the noisy signal.

Emergency access: When the IMD Shield is off or not present, the system **fails open** by reverting to the status quo (cleartext).



IMD Shield Caveats

- We assume that the IMD Shield can establish a secure channel with a legitimate IMD programmer. In practice, an out-of-band key exchange (e.g., tactile or visual) might suffice.
- Our software-radio prototype of the IMD Shield is much larger than a production-ready wearable device would be.
- How should a wearable IMD Shield be powered?
- A sufficiently powerful adversary can overpower the IMD Shield to talk to the IMD, but in this case the IMD Shield sounds an alarm.

Timeline of Recent Related Work

2005 — [ACISP 2005]
Rieback et al. implement friendly jamming for privacy in the **RFID Guardian** device

2008 — [Pervasive 2008]
Halperin et al. propose a **threat model** for IMDs and highlight **theoretical risks**

2008 — [Oakland 2008]
Halperin et al. identify and exploit security and privacy flaws in an **implantable defibrillator**, propose defenses

2009 — [HotSec 2008]
Denning et al. propose the **communication cloaker**, conceptual ancestor of IMD Shield. Companion device requires IMD to be made aware of it

2010 — [HealthSec 2010]
First USENIX Workshop on Health Security and Privacy—papers include "Privacy Challenges for Wireless Medical Devices" and "Insulin Pump System Security"

2010 — [MobiCom 2010]
Choi et al. demonstrate single-channel, full-duplex wireless communication. Requires half-wavelength antenna separation (vs. IMD Shield's arbitrarily small size)

2011 — [INFOCOM 2011]
iJam (Gollakota et al.): **Jam while receiving** to prevent eavesdropping of a protected signal; OFDM-based technique requires protected device to be modified. IMDGuard (Xu et al.): **Another approach** adds crypto to IMDs and a wearable device that acts as an authentication proxy; requires IMDs to be modified.

Today — [SIGCOMM 2011]
IMD Shield incorporates full-duplex wireless and friendly jamming to combat eavesdropping and adversarial commands

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