Trust of Medical Devices, Applications, and Users in Pervasive Healthcare

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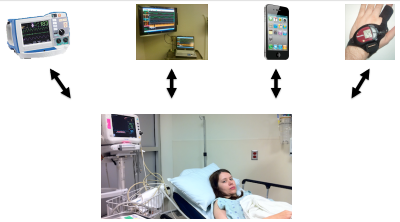
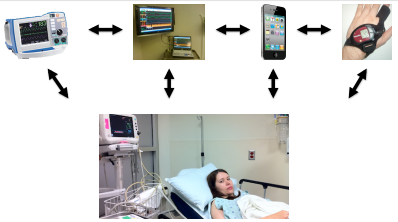
UC Davis Computer Security Laboratory
PETRA 2011

A Patient in a Pervasive Healthcare Environment



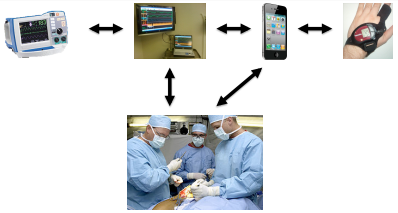
Many devices monitor the patient

Sensors, Devices, Doctors, and the Patient Form a Network



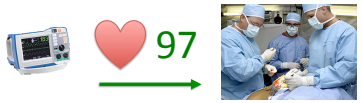
Sensors and devices send each other data…

Sensors, Devices, Doctors, and the Patient Form a Network



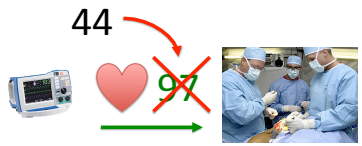
…and communicate with doctors and nurses

Devices May Be Compromised or an Insider May Manipulate Them



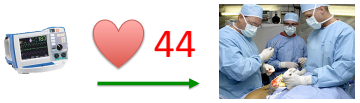
Example: a malicious nurse alters the data from a device

Devices May Be Compromised or an Insider May Manipulate Them



Example: a malicious nurse alters the data from a device

Devices May Be Compromised or an Insider May Manipulate Them



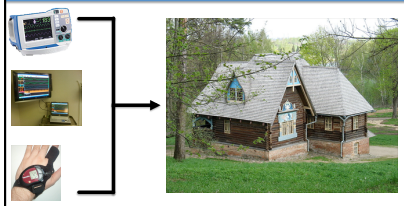
The altered data is used by a doctor or device, killing the patient!

Devices May Malfunction For Non-Malicious Reasons

Devices might provide bad data

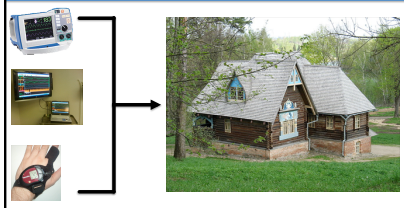
…or no data!

Threat Model



In a pervasive computing environment, there may be much less control over devices than in a hospital

Threat Model



This makes the threat model very different!

Threat Model

- The hospital can not control every data source
- Patients, caregivers, or even strangers may have access to sensors and devices
- Data sources may be networked, and could be attacked from outside!

Healthcare Trust Models

- Other trust models grant or deny access to patient data, allow certain people to add to existing records
- These extend access control mechanisms in Role Based Access Control

Example of Role Based Access Control

Read Patient Data ✓

Doctors can read and append data, but not alter it

Example of Role Based Access Control

Append Patient Data ✓

Doctors can read and append data, but not alter it

Example of Role Based Access Control

Alter Patient Data ✗

Doctors can read and append data, but not alter it

Example of Role Based Access Control

Read Patient Data ✓

Patients can only read data, not append or alter it

Example of Role Based Access Control

Append Patient Data ✗

Patients can only read data, not append or alter it

Example of Role Based Access Control

Alter Patient Data ✗

Patients can only read data, not append or alter it

Healthcare Trust Models

- Protect patient privacy and data integrity by restricting access to those who are trusted
- Some address context sensitivity
- Some address the trustworthiness of users to *access* data
- Don't examine data *source* trustworthiness!
- These models protect patient privacy, and medical record integrity

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Why This is a Problem

- They don't provide assurance that the data sources are trustworthy
- This leaves data sources such as sensors and devices open to attack and manipulation.
- We'd like to provide assurance that patent data *sources* are trustworthy
- Existing healthcare trust models don't let us do that!

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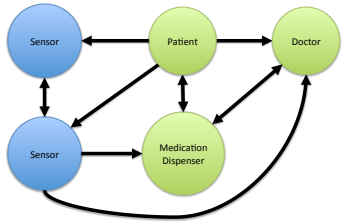
Example – Insider Manipulates Data From a Device



Sensors monitor the patient

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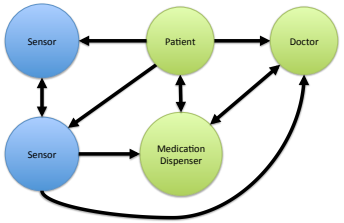
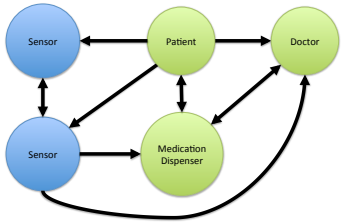
Example – Insider Manipulates Data From a Device



Sensor data goes to doctor and medication dispenser

Example – Insider Manipulates Data From a Device



Dispenser medicates patient based on sensor data and doctor's instructions

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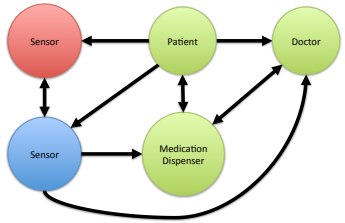
Example – Insider Manipulates Data From a Device



Attacker alters sensor data output

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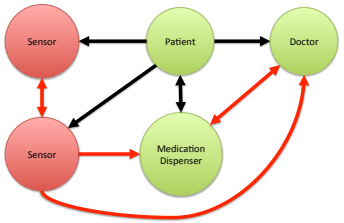
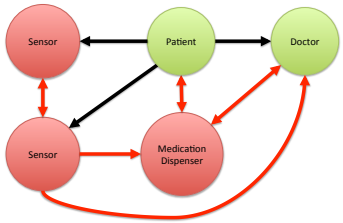
Example – Insider Manipulates Data From a Device



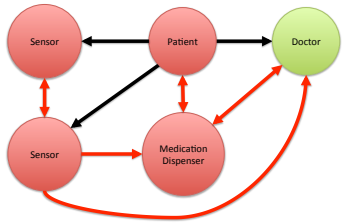
…producing incorrect data throughout the network

Example – Insider Manipulates Data From a Device



…Causing the patient to be incorrectly medicated

Example – Insider Manipulates Data From a Device



…Killing the patient!

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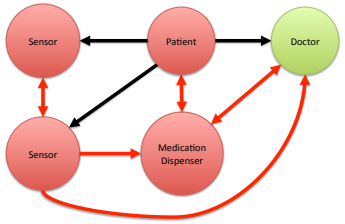
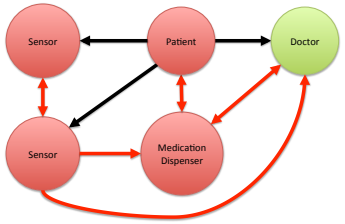
Example – Insider Manipulates Data From a Device



Data privacy and integrity models don't deal with data sources

Example – Insider Manipulates Data From a Device



A different trust model is needed

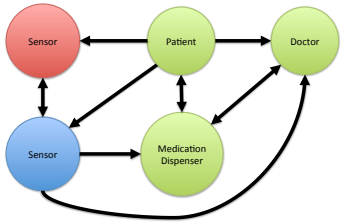
What we need in a trust model

- Doctors, patients, and devices should be able to determine how much data from different sources can be trusted relative to each other, or to baselines
- Using that information, we can determine whether to utilize information from each source in different contexts

The Solar Trust Model

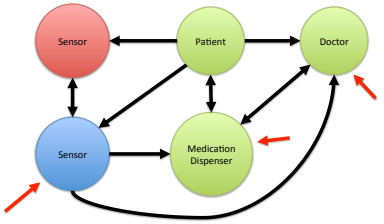
We can apply the Solar Trust Model to solve this problem

How the Solar Trust Model Handles a Compromised Data Source



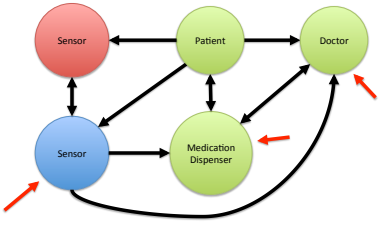
Data source is compromised…

How the Solar Trust Model Handles a Compromised Data Source



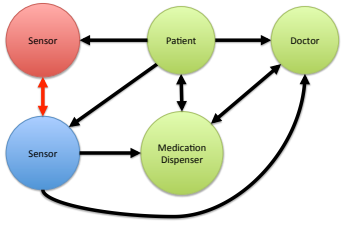
Data consumers have trust policies or heuristics

How the Solar Trust Model Handles a Compromised Data Source



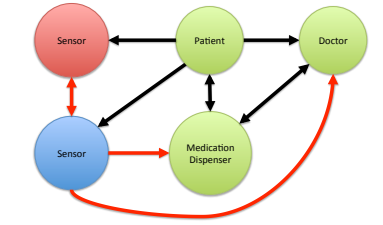
Policies describe the conditions under which data is trusted

How the Solar Trust Model Handles a Compromised Data Source



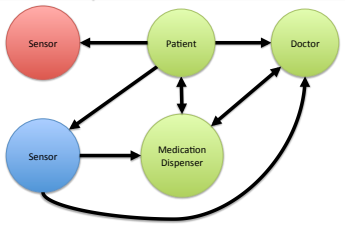
Data from the compromised source violates those policies

How the Solar Trust Model Handles a Compromised Data Source



Paths including the compromised sensor become less trustworthy…

How the Solar Trust Model Handles a Compromised Data Source



…and eventually are not trusted!

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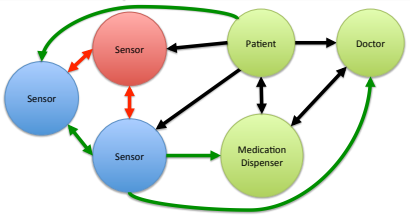
How the Solar Trust Model Handles a Compromised Data Source



If the network is more complex…

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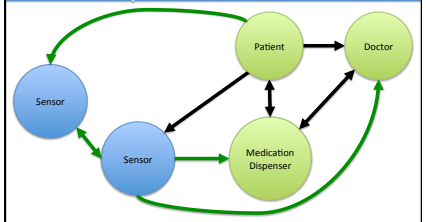
How the Solar Trust Model Handles a Compromised Data Source



The model can route around the compromised sensor

Conclusion

- Pervasive healthcare has a different threat model than traditional healthcare
- Traditional models address patient privacy and data integrity, but not trust of data sources
- The STM addresses trust of data sources, providing assurance to patients and doctors that data sources are less open to manipulation, malfunction, and attack

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Questions?

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