Chapter 7
The Role of Time in Health IoT

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ABSTRACT

As the biological processes in the body change constantly, comparable measurements should be taken simultaneously in time and place. In practice, this is hard to achieve. Synchronicity is required to certify medical accuracy for a new device by reference to a certified one. In a typical health IoT, synchronicity cannot be enforced procedurally and timing needs to be part of the network architecture. Popular examples are in blood pressure measurement. Putting the blood flow in a known pinch-off situation performs synchronization. But this principle cannot be extended to other non-invasive measurements. Hence the chapter proposes to synchronize on basis of the heart rate extracted from the blood flow at arbitrary positions on the body. This models the blood flow in the body and relates all to the rhythm of the heart. It brings existing phenomena into a single, multi-level model that allows wireless networked wearables into a single health-monitoring scheme.

INTRODUCTION

The physical effect of sound propagation is rumoured to have decided the Olympic gold medal for 500 metres speed skating in Sochi 2014. The start of the race is sounded by a shot as part of a ceremony that brings the racers to attention. The competition has become very challenging over the past decades. Nowadays differ-

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ences of milliseconds determine to have gold or nothing. Smeets and Mulder made such a race, but it was shown afterwards that the real difference, being everything else equal, was made by the starting position on the arena. The person closer to the centre hears the shot slightly sooner. Such an advantage can easily decide the championship when the run itself is short also.

The phenomenon is not rare. In the eighties, the on-going miniaturization has cast attention to the different scaling of the clock and the logic signals. Clocks are passed over different paths on the distribution network and will therefore delayed differently. Then time can be different where after following different paths the same clock is logically exerted. The remedy has been to divide the chip area into iso-chronic areas, parts where the differences in time definition is still negligibly small. Communication between such parts will be by more elaborate, clock-less mechanisms. This is called globally asynchronous, locally synchronous or GALS communication (Spaanenburg, 1987).

These are only two of the many situations where two observations have problems to be synchronized. A new branch of the tree is mHealth. The heart takes the role of the atomic clock for the human body. It pumps the blood around to distribute the clock event to the organs. The heart rate is not a known and constant value but can be reasonably determined invasively; however the determination of the exact timing will be harder to achieve.

In this chapter the role of timing in the overall discussion on blood flow analysis is looked at. Then we step up the involvement of timing within the extraction of blood pressure (BP). From there the attention is broadened to networked collections of health devices. In the end we extend the issues to system reliability, the main requirement to any product in the health sector.

BLOOD FLOW ANALYSIS

Deep down, the heart drives the blood circulation system. However, its main pipe has a flexible wall and hence behaves non-linearly in response to the applied pressure. The transients in the heartbeat will gradually be smoothed while passing through the artery. Everywhere in the blood circulation system, the heartbeat can be found in a related but gradually different way. Ultimo, some non-invasive measurements at spread-out locations can be used to model an invasive measurement at the heart.

Circulation Diagnosis

Electrocardiogram (ECG) measurements need proper placement of a number of probes. If accurately executed, the signal can be detailed enough allowing more