

Chapter X

Optimization and Prioritization of Cardiac Messages

This chapter presents a signal theory viewpoint concerning diagnostic parameter datastreams. Particular diagnostic parameters are considered as a time sequence representing certain medical variables as time-dependent. Since the parameters represent various aspects of electrical heart activity (e.g., the depolarization rate, the re-polarization speed, etc.), their variability, and therefore the bandwidth of the corresponding signal, is limited by physiological relations. For example, a sinoatrial node stimulation rate may accelerate or decelerate by up to 20% on a beat-to-beat basis, while the ST segment depression representing heart cell re-polarization is dependent on blood oxygenation in the coronary arteries and thus is not expected to significantly change within a five-minute period. The minimum sampling frequency is estimated by analyzing the maximum expected variability. Due to the nature of the parameters, the sampling frequency ranges from 0.0000118 Hz (once a day) to 4 Hz, which is a maximum physiological heart rate.

The observation of the patient-doctor relationship justifies the common belief identifying two main reasons for medical examinations as: (1) expiry of the validity period of the precedent examination, and (2) sudden deterioration of the patient's condition (subjective or objective). Currently, the dependence of the patient examination frequency on his or her status has no analogy in automated diagnostics. This chapter presents a proposal of medically justified modulations of the frequency of cardiac reporting, implemented in a client-server distant cooperation model. The

supervising center analyzes incoming messages and other conditions, and issues the desired reporting interval back to the remote device. As a result of the authors' tests and simulations, this method may reduce wireless channel usage and increase remote autonomy up to three times.

Although the raw electrocardiogram is digitized with a constant frequency, the medical importance of particular signal strips varies significantly. Similar to a paper record, the cardiac message may be a confirmation of a patient's state of health as well as being a carrier of an emergency alert. That constitutes a background for another scientific challenge in electrocardiography. We explore the opportunities opened up by the modification of content of the data packet and its priority in the network as depending on diagnostic data. The patient-oriented analysis performed by the PED separates all unexpected patterns, as well as divergences of parameters marked by a newly proposed interest attribute. Such processing favors singularities as an indication of abnormal heart activity of unknown origin and potential danger. On the other hand, the hypothesis-driven analysis is oriented to detect minor changes in selected parameters that may be also considered as severe. Beyond the regular report packages, these alerts are transmitted to the SuSe with a high priority attribute set. This adaptation reduces the cost of long-term monitoring and speeds up messages in urgent cases.

VARIABILITY ANALYSIS OF MOST COMMON DIAGNOSTIC PARAMETERS IN ECGS

The electrocardiographic signal is the carrier of all diagnostic parameters derived from it, and the need for high sampling frequency is justified by expectation of high-fidelity digital representation of analog signals. Within the ventricle contraction period represented by the QRS complex, the signal frequency is occasionally high, but for the rest of the signal there is a considerable redundancy of adjacent samples (Bailey et al., 1990; Augustyniak, 2002). This redundancy was the key point of the family of algorithms for the ECG compression based on a temporal similarity of samples. Although it is theoretically possible, there is no diagnostic parameter showing variability as high as the raw representation of a cardiac electrical field.

Although changes in electrical heart activity are continuous, they are rarely observed and reported within a heartbeat. The only exception is probably a baseline and noise level estimation that should reflect abrupt changes in noise power and thus alter the ECG measurement conditions. These measurements are used in the compensation or improvement of the signal within short strips (a few samples), however their local values are rarely stored in the internal database and included in the report. In most cases the signal quality estimate and the baseline level are

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