

Research Article

Cyborgan OS: A Lightweight Real-Time Operating System for Artificial Organ

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The software of artificial organ is more and more complex, but it lacks real-time operating system to manage and schedule its resources. In this paper, we propose a lightweight real-time operating system (RTOS) Cyborgan OS based on the SmartOSEK OS. Cyborgan OS optimizes and improves it from the code size, context switch, low power consumption, and partial dynamic update, making it suitable for the artificial organ control system. Finally, we use the heart blood pump model to analyze the task allocation and execution sequence as well as the code size of the whole program. In this application, the maximum space occupied by the code is only 15 kB, which is suitable for most microcontrollers.

1. Introduction

Cyborg is a biological creature whose functioning has been enhanced through integration of mechanical, electrical, computational, or otherwise artificial components [1]. Among them, the artificial organ and cyborg insect are typical representatives [2, 3]. From a perspective provided by Zheng et al., the human will be enhanced by artificial electromechanical components and become new cyborg intelligent systems [4, 5].

In the field of artificial organs, a lot of research work is focused on organ materials, mechanical structure design, application systems, and so on [6, 7]. Kosaka et al. have proposed a remote artificial heart monitoring system based on Internet and noninvasive sensors, which can manage the physiological state of patients and the working state of artificial heart in real time and effectively [8]. The authors in [9] propose a microcontroller pacemaker for bradycardia pacing, along with a PC-based programmer. Its algorithm is implemented in Arduino microcontrollers, which is programmed using PC and MATLAB. Markovic et al. design a blood pump for a wearable artificial kidney device. Its control system for the operation of the blood pump is composed of a central computer, power cards, and position

measurement cards [10]. The power card contains a microcontroller STM32F103, which controls the power switch of the blood pump. Despite all those accomplishments, according to our limited knowledge, there is no special operating system for artificial organs. As the artificial organs are becoming more powerful, especially the application of smartphones in artificial organs, the complexity of artificial organ is greatly increased [11]. It is necessary to resort to unified management and scheduling of hardware and software resources of artificial organs. Therefore, it is advisable to adopt an embedded RTOS as the basic software platform of artificial organs. Limited by the physical conditions of human body, microcontrollers used in artificial organs generally have limited memory and very small battery capacity. This application scenario requires the embedded RTOS to be lightweight and of low power consumption at system level to extend battery life.

This paper designs and implements a lightweight real-time OS for artificial organs and names it Cyborgan OS. The main contributions of this paper are as follows:

- (1) Lightweight kernel: we implement a 10 kB level kernel based on priority scheduling, which is suitable for most Microcontroller Units (MCU)

