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嵌入式实时操作系统任务调度算法改进

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摘　要: 在嵌入式系统中,任务调度算法的好坏很大程度上决定了系统的性能。本文分析了嵌入式实时系统中有代表性的静态以及动态调度算法,在此基础上,结合静态和动态算法各自的优点,提出一种新的任务调度算法 NEDF。

关键词: 嵌入式实时操作系统;调度;动态; EDF

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嵌入式实时操作系统兼有嵌入式和实时性的特点。作为一种嵌入式操作系统,它具有嵌入式软件共有的可裁剪、低资源、低功耗等特点;作为实时操作系统除了要满足应用的功能需求以外,更重要的是还要满足应用提出的实时性要求。实时操作系统所遵循的最重要的# # 设计原则是:采用各种算法和策略始终保证系统行为的可预测性。实时操作系统的首要任务是调动一切可利用的资源完成实时控制任务。如何使任务集内各任务满足各自的时限,使系统得以正常、高效率工作的任务调度算法一直是实时系统领域内研究的焦点。根据其应用领域及追求精简、高效角度的不同,任务调度算法从简单的合理安排任务循环,发展到基于优先级的速率单调调(RMS)、最早时限优先(EDF)等算法。任务调度算法的好坏以及执行效率直接关系到嵌入式内核的应用范围及实时性程度。

1　各种实时操作系统的实时调度算法可以分为如下三种类别

基于优先级的调度算法(Priority- driven scheduling- PD)、基于 CPU使用比例的共享式的调度算法(Share- drive scheduling- SD)、以及基于时间的进程调度算法(Time- driven schedulinq- TD),下面对第一种调度算法进行重点介绍。

基于优先级的调度算法给每个进程分配一个优先级,在每次进程调度时,调度器总是调度那个具有最高优先级的任务来执行。根据不同的优先级分配方法,基于优先级的调度算法可以分为如下两种类型

1.1　静态调度

静态调度是在系统开始运行前进行调度的,严格的静态调度在系统运行时无法对任务进行重新调度。静态调度的目标是把任务分配到各个处理机,并对每一处理机给出所要运行任务的静态运行顺序。静态调度算法实现简单,调度的额外开销小,在系统超载时可预测性好。但也具有很大的局限性,例如资源利用率低、受系统支持的优先级个数限制以及灵活性和自适应性差等。

1.2　动态调度

在嵌入式实时系统中,动态调度依赖于任务的优先级。优先级可以静态分配或者依据不同的特征参数,如截止时间、空闲时间或关键性(即任务的重要程度)等进行动态分配。动态调度可以是抢占式的或非抢占式的。当检查到一事件时,动态抢占式算法立即决定是运行与此事件相关的任务,或继续执行当前的任务;对于动态非抢占式算法,它仅仅知道有另一个任务可以运行,在当前任务结束后,它才在就绪的任务中选择一个来运行。以下介绍的是一个经典的动态调度算法:最早截止时间优先算法 EDF。

2　最早截止时间优先算法 EDF

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最早截止期限优先算法(EDF, Earliest Deadline First)也称为截止期限驱动调度算法(DDS, Deadline Drived Scheduling),是一种动态调度算法。在进程执行期间,根据它的启动时间改变优先级。它以最后截止期限的顺序指定优先级。优先级最高的进程是距离最后截止期限最近的进程,优先级最低的进程是距离最后截止期限最远的进程。

此算法根据任务满足截止期限的紧迫性来修改任务的优先级,以保证最紧迫的任务能够及时完成。当系统的负载相对较低时,这种算法非常有效。但是,当系统负载极端沉重时会引起大量的任务发生时间错误,甚至可能导致 CPU 时间大量花费在调度上,在这时系统的性能还不如 FIFO方法。根据计算,当系统负载超过 50% 时系统性能急剧下降。EDF的实现比 RMS要复杂得多,主要问题在于如何使进程按照到达最后截止期限的时间排序,因为进程到达期限的时间在执行期间是变化的,这样进程就无法给以事先排序。每一个进程结束时,优先级都必须重新计算。操作系统在调度过程的最后一步选择优先级最高的就绪进程执行。如果一任务集按 EDF算法可调度,当且仅当 U <= 1即,EDF可以达到 100% 的利用率。

EDF是一种动态调度策略,可以实现很高的 CPU利用率,可以调度 RMS不能合理调度的任务集,但是它的系统开销比较大,很难诊断出即将过载的可能性。因此,EDF比较适用于软实时系统。在一些实时应用中,某些进程偶然错过了最后截止期限是可以接受的,这时 CPU的利用率就成为评价调度策略的一个关键指标,这一指标的实现一般都要通过应用具有更高开销的、更复杂的调度策略来换取。

3 调度算法的选择

嵌入式实时系统中资源是非常有限的,所以开销要尽可能小。开销主要包括运行开销和调度开销。运行开销与队列分析和从调度队列中增加、删除任务相关。每个任务在一个调度周期内至少被阻塞和唤醒一次,所以任务调度器在一个周期内不得不对一个任务进行两次选择。静态算法根据任务的执行频率设置优先级,有较小的运行开销,但执行频率最高的任务不一定是最重要的。EDF算法中则是对整个任务列表的调度开销进行全面比较,选择最高优先级任务进行调度,有较小的调度开销,但对多个任务具有同一优先级的情况考虑不足。

基于优先级的调度算法在实时进程调度中使用很广泛,静态优先级调度算法根据应用的属性来分配优先级,其可控性较强,而动态优先级调度算法在资源分配和调度时具有更大的灵活性。如果结合这两种算法的优点,扬长避短,就能够对实时任务进行更合理、更高效的任务调度。利用最著名的动态优先级调度算法 - EDF算法的高 CPU利用率、可调度较大的任务集的特点,结合静态优先级调度算法的可控性就形成了一种新的调度算法 - NEDF 调度算法(New Earliest Deadline First)。

4 NEDF算法

4.1 NEDF算法概述

NEDF算法以任务的截止期限作为任务调度的首要指标,但不是唯一的指标。当两任务的截止期限在一定的 IM 值范围内时,根据任务的优先级来决定要运行的任务,这时以任务的静态优先级来选择任务,一定程度上增强了算法的可控性。确定任务的静态优先级,主要依据有以下几个。

(1)执行时间

以执行时间为依据,执行时间越短,静态优先级越高。

(2)任务周期

以任务周期为依据,任务周期越短,静态优先级越高。

(3)任务的 CPU利用率

任务的 CPU利用率为任务执行时间与任务周期的比值(生)。仟各的 CPU利基于 Linux的实时操作系统研究用率越高,静态优先级越高。

(4)任务紧急程度

根据任务的紧急程度,人为安排任务的优先级。任务越紧急,静态优先级越高。

4.2 算法说明

先假定任务的优先级均不相同,则在某个调度时刻 t,NEDF算法先查找距截止期限最近的任务。这时,可能有多个任务的截止期限相等或较为接近。如果截止期限相等,则选择高优先级的任务运行。如果截止期限均不相等,且最小截止期

限比次小截止期限小许多,则选择最小截止期限的任务运行。若最小截止期限与次小截止期限的差值在一定的 IM值范围内,则选择高优先级的任务运行。截止期限 IM值的设定应保证最高优先级任务能够如期完成,一般可取最小相对截止期限的值,以确保在最小相对截止期限的周期范围内,最高优先级任务能够优先运行。

4.3 算法流程

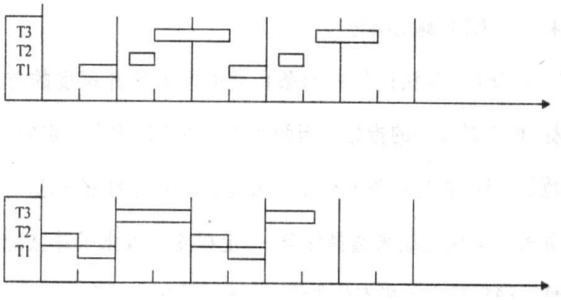
采用 NEDF调度算法的任务可用五元组 (s, P, e, D, pr)来表示,其中 pr为进程的静态实时优先级。其算法流程如下:

(1)在 t0时刻,选取最早截止期限接近的两个任务运行 T1, T2;

(2)如果 T1, T2的截止期限差值小于阂值,则选择优先级高的任务运行;

(3)如果 T1, T2的截止期限差值大于闽值,则选择截止期限最小的任务运行;

(4)在 t1时刻,按照上述规则进行。



假设有三个任务 T_1, T_2, T_3,其中 $D_1 < D_2 < D_3$, $pr_1 < pr_2 < pr_3$ 按照 NEDF算法上述任务集的运行顺序为: T_2, T_1, T_3

4.4 嵌入式实时 **Linux**下 **NEDF**算法分析:

F= 1000Hz, t0= 1ms,时钟中断时间不超过 2μs,即 e_0= 0.002ms阻塞时间

$b_1(np)$= ([0.1/1]+ 1)= 2ms,

$b_2(np)$= t0= 1ms,

$b_3(np)$= ([0.1/1]+ 1)= 2ms,

根据 NEDF算法公式可以得知:

$$i=1,\ \sum_{k=1}^{n}\frac{e_k}{\min(d_k,p_k)}+\frac{b_i}{\min(d,p)}=\frac{0.002}{1}+\frac{1.064}{6}+\frac{1.864}{8}+\frac{5.004}{25}+\frac{1}{3}=0.94583<1$$

$$i=2,\ \sum_{k=1}^{n}\frac{e_k}{\min(d_k,p_k)}+\frac{b_i}{\min(d,p)}=\frac{0.002}{1}+\frac{1.064}{6}+\frac{1.864}{8}+\frac{5.004}{25}+\frac{1}{8}=0.73749<1$$

$$i=3,\ \sum_{k=1}^{n}\frac{e_k}{\min(d_k,p_k)}+\frac{b_i}{\min(d,p)}=\frac{0.002}{1}+\frac{1.064}{6}+\frac{1.864}{8}+\frac{5.004}{25}+\frac{2}{25}=0.69249<1$$

根据 $W_i(t)=e_i+b_i+\sum_{k=1}^{i-1}\left|\frac{t}{p_k}\right|e_k,\ 0<t=\min(d,p)$得最大响应时间:

$$\omega_1(t)=e_1+b_1+\left[\frac{t}{p^0}\right]e_0+\left[\frac{t}{p^2}\right]e_2=1.064+2+0.002[t]+1.864\left[\frac{t}{8}\right]$$

$$\omega_2(t)=e_2+b_2+\left[\frac{t}{p^0}\right]e_0=1.864+1+0.002[t]$$

$$\omega_3(t)=e_3+b_3+\left[\frac{t}{p^0}\right]e_0+\left[\frac{t}{p^1}\right]e_1+\left[\frac{t}{p2}\right]e_2=5.004+2+0.002[t]+1.064\left[\frac{t}{6}\right]+1.864\frac{t}{8}$$

经过迭代运算, $W_1(t)$= 4.974ms, $w_2(t)$= 2.87ms, wa(t)= 15.822ms.从上述结果可以看出,在嵌入式实时 Linux环境下,采用 NEDF调度算法,每个任务调度条件均满足,任务集是可调度的,每个任务的电大响应时间均小于截止期限,并且实时优先级高的任务的响应时间更容易得到保证,一定条件下对优先级高的任务更有利。

5 结束语

通过对实时系统中的经典调度算法进行分析、比较,在周期性任务组成的实时系统中,结合静态算法具有较小运行开销和动态 EDF算法具有较小调度开销的特点,对任务调度算法乾地了改进,是对嵌入式系统调度策略的一次有益探索。

参考文献:

[1]毛德操,胡希明. Linux内核源代码情景分析 [M].浙江: 浙江大学出版社, 2001.

[2]李善平,陈文智.边学边干 Linux内核指导 [M].浙江: 浙江大学出版社, 2002.

[3]周培德.计算几何 - 算法分析与设计 [M].北京: 清华大学出版社, 2000.

[4]唐.实时操作系统应用开发指南 [M].北京: 中国电力出版社, 2002.

[5] Liu CL, Lay land J. Scheduling algorithms for multiprogramming in a hard real- time enviro nment [J]. J. ACM. 1973. 20(1): 46- 61.

[6] Batptiste Pape C L. Nuijten w Constraint - based scheduling Applying constraint programming to scheduling problems [M]. Boston: Kluwer Academic Publishers, 2001.

[7] Briand L, Roy D. Meeting deadlines in hard real. time systems: the rate monotonic approach [M]. USA: IEEE Computer Society, 1999.

[8] Linux内核源代码 9.0[Z].

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Abstract This paper presents a linear motor supervisory system. The supervisory system consists of incremental linear encoder, square-wave forth-times frequency and identification direction circuit, thermocouple, ADAM4000 series industrial control I/O modules, PCI-1780 multiple channel counter card and PC Auto configuration software. It can supervise displacement, pull or push force, and winding multi-point temperature of the linear motor. The whole blueprint and implementation process of the linear motor supervisory system are discussed in details in this paper.
Keywords Linear motor Incremental linear encoder Thermocouple Force transducer

Abstract In view of the wide demands on uninterrupted power supply, and based on the work principle of voltage sampling, detection and comparison, we realized the automatic switchover with double power supply by using single chip to check the power supply and its relative control, and discussed the hardware architecture, software establishment and anti-interference measurement in detail.
Keywords Monolithic integrated circuit Cut installment Double Power source Control

Technical Communication

Abstract With the development of the LCD Interface of UAV Landing System Ground Beacon Controller, this paper introduces the application of the LCD module MSP-G320240DBCW of embedded controller SED 1335, explains the interface technology of the module and MCU, and the programming skills of Chinese character dot-matrix LCD display and figures refresh conversion display, and narrates the application of the state transformation method in the keyboard control of man-machine interface.
Keywords SED 1335 MSP-G320240DBCW LCD MCU Man-machine interface

Abstract The design of system access right on database level is always the core of the enterprise information system. It always takes up more than half the design time to develop. This article introduces a non-traditional, hierarchy-oriented security framework, and makes an in-depth comparison with the traditional security design.
This design principle is more similar to Windows OS. In Windows OS, once a user obtains the access right to a folder, he can naturally obtain the access right to its sub-folders. This article also makes a brief research on the future development of this kind of security framework.
Keywords Access right design Implicit assertion Hierarchy-oriented Database design

Abstract There are many software used in industrial control fields which are designed in single operation system such as DOS and Windows systems. But at many times, it requires to operate on more than one system. This article aims at the research on serial communication between DOS and Windows systems. And we have designed and realized the serial communication through RS232 between the sending computer in DOS system and the receiving computer in Windows system.
Keywords RS232 Serial communication Computer interface

Abstract This paper introduces a scheme realizing the transmission of images with secret messages, which combined chaos hash with wavelet. Firstly, it used Arnold transformation to encrypt the transferred images by chaos hashing. Then, embedded the wavelet transformed secret key images into the wavelet transformed carrier images. Through network transmission, passed the acceptor detection and loaded the secret key images from carriers. Finally, recovered the secret key images by anti- transformation.
Keywords Chaos hash Wavelet analysis Information hiding Secret key images

Abstract A weighted target optimal solution for Box-Cox transformation is constructed by taking regression coefficient t, muticollinearity and heteroscedasticity into consideration. Use the dynamic spreadsheet of Microsoft Excel array functions to reversal seek global optimizing parameters of BOX-COX transformation based on robust GRG2 algorithm. The example illustrates the modeling course and the satisfying applications for multicollimearity and autocorrelation in regression .
Keywords Excel Modeling Array functions BOX-COX transformation Robust GRG2 algorithm Global optimizing

Abstract The capability of an embedded system is determined, to a great degree, by the underlying task scheduler of RTOS. This article firstly analyzes the typical static scheduling algorithm and dynamic scheduling algorithm in RTOS. Then, it presents a new algorithm(NEDF) by combining the advantages of both the static scheduling algorithm and the dynamic scheduling algorithm (EDF).

Keywords RTOS Task scheduling Dynamic EDF

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Abstract The application of time synchronization on distributed system become more and more important. In this paper, time synchronization technology and fault-tolerance time synchronization strategy are studied and the error analysis method is given. The Sliding Window Algorithm is applied in fault-tolerance time synchronization strategy.

Keywords Distributed system Time synchronization Fault-tolerance strategy

XIA Xin HU Bin (Information Science and Technology School, Nanjing Agricultural University, Nanjing 210095, *China)*

Abstract With the rapid development of the network technology and the increase of the network bandwidth, network security is becoming more and more important. As a different network technology to firewall, IDS becomes more and more popular. But with the more complicated intrusions and the more sharing resources, single IDS does not satisfy our needs. CIDF, introduced by this passage, standardizes the framework of IDS, the format and method of data exchange. IDSs corresponding to CIDF will work together better and become more secure and reliable. How to use LDAP to make components of CIDF communicate is also explained and analyzed.

Keywords IDS CIDF LDAP

Learners's Garden

WANG Xu-yang LU Ji-guang (Dept. of Computer Science, South-central Univ. for Nationalities, Wuhan 430074, *China)*

Abstract Firstly, several strategies for packet filtering in Windows are introduced in this essay. Then, their advantages and disadvantages are presented. Finally, we take two examples on personal firewalls of the application of packet filtering in Windows.

Keywords Personal firewall SPI TDI NDIS

LI Xiu-qin LI Xiao-lei SUN Juan (North China University of Water Conservancy and Electric Power, Zhengzhou 450008, *China)*

Abstract Aiming at the problem of communication between a great quantity of heterogeneous databases, a kind of data exchange technology based on XML was proposed. In the process of achieving, we further studied the method of exchange between XML schema and relational schema, and put forward the exchange algorithm and exchange regulation. Besides, analyzed the exchange method between semantic constraint of the XML schema and integrality constraint of the relational schema.

Keywords XML schema Relational schema, Exchange algorithm Semantic constraint Integrality constraint

ZHU Yu-xin ZHANG Jin-zong (College of Environmental and Planning of Liaocheng University, Liaocheng 252059, *China)*

Abstract The technologies of digital maps and GIS have made great progress since 1980s. The applications and developments about the technologies have also led to the generation of electric maps, in which more spatial information was emphasized. By the demonstrations of elementary functions of electric maps such as drawing grid lines of longitude and latitude, and zooming in and zooming out pictures, you can understand the advantages of object-oriented models and the strong functions of Tcanvas class.

Keywords Object-oriented Delphi Tcanvas

WU Rong (Department of Mathematics, Huaqiao University, Quanzhou 362021, *China)*

Abstract Web log mining is the application of data mining to web server logs in order to discover the behavior patterns of website visitors, and furthermore to improve the websites' structures or to provide individual services for users. This paper, exploring the user identification algorithm of the log mining, proposes a user identification algorithm with multi-binding conditions.

Keywords Web log mining Data preprocessing User identification

SHI Jun (Shanghai Top Institute of Information Technology, Shanghai 201300, *China)*

Abstract This thesis introduces a method of constructing compatible plug-in objects in Java by taking examples, and puts forward that it is useful to analyze, design and write codes by combining "black box" operation and OOP's polymorphism.

Keywords OOP Java plug-in "black box" operation, Interface Abstract Super-class Game

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