编号:_____

陕西高等学校科学技术奖励推荐书

一、成果概况

<table>
<tr><td>成果名称</td><td colspan="5">基于 ZigBee 技术的无线物联网路灯节能管控系统研究</td></tr>
<tr><td>主要完成人</td><td colspan="5">刘彦戎；商莹；王丽君；刘斌</td></tr>
<tr><td>主要完成单位
（公章）</td><td colspan="5">陕西国际商贸学院；陕西科技大学</td></tr>
<tr><td>成果类型</td><td>A.基础研究、应用基础研究
B.技术开发、发明、推广
C.软　科　学
D.科普类成果
选（　A　）</td><td>专业评审组</td><td colspan="3">A.数理力学　E.机械　J.动力电气　N.生物技术
B.电子信息　F.轻工　K.地球科学　O.医药卫生
C.化学化工　G.纺织　L.材料科学　P.软 科 学
D.环境科学　H.工程建设　M.农林畜牧　Q.科 普 类
选（ B ）</td></tr>
<tr><td colspan="2">二级学科名称</td><td colspan="2">计算机应用</td><td>项目起止时间</td><td>2017-01-01 至
2018-12-31</td></tr>
<tr><td colspan="2">三级学科名称</td><td colspan="2"></td><td>总经费</td><td>10 万元</td></tr>
<tr><td colspan="2">任务来源及编号</td><td colspan="2">省部级计划基于 ZigBee 技术的无线物联网路灯节能管控系统研究 （2017JM6111）咸阳 2015KT-08</td><td rowspan="2">评价形式</td><td rowspan="2">A.鉴定　B.评审
C.验收　D.专利
E.检测　F.引用评价
选（ A、B ）</td></tr>
<tr><td colspan="2">已获奖励情况</td><td colspan="2"></td></tr>
<tr><td colspan="4">学校推荐意见
本成果属实，人员排序无异议，无知识产权纠纷，同意推荐。
（公章）　　年　　月　　日</td><td colspan="2">推荐等级　三等奖</td></tr>
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二、内容简介

1.成果简介

该项目属于电子信息领域，其中涉及计算机软件技术、计算机硬件技术、物联网技术、无线通信技术等。

（1）主要研究内容

该项目主要是在陕西省咸阳市路灯监控管理系统的基础上进行了基于 ZigBee 无线路灯节能管控系统的研究。首先用 UML 模型阐述了咸阳市路灯管控系统的功能需求和技术需求，提出了基于 ZigBee 技术的无线物联网的节能管控系统研究的系统设计思想。其次，对咸阳市的整体路灯进行规划系统设计和建立新的开发方案，包括系统层次模型、硬件构架、通信网络和数据模型的搭建。再次，采用大功率电子镇流器实现信息采集和控制功能的基础上，利用 ZigBee 和 GPRS 构建短距离通信与长距离通信结合的通信网络解决系统的信息传输问题，尤其是解决了咸阳市路灯信号控制输出迟缓的问题，并采取了 C/S 和 B/S 的混合构架模式,该系统降低了数据存储和数据查询的负担,提高了运作效率,同时以 Asp.Net 和 SQL Sever 为开发平台，应用 jQuery EasyUI 前端框架和 JavaScript 编程语言构建了界面美观、系统功能强大，性能比较稳定的人际操作平台。该系统已部分应用到咸阳市渭城区三条街道（渭阳东路、抗战南路和抗战北路），且达到了输出信号稳定不延迟和遇特殊环境时实现自动切换的控制模式。

（2）科学价值

该项目较好的实现了道路照明与景观照明的精准管理。无线路灯管控系统可充分感知城市道路中的车流信息，从而实现对灯光的精准控制，在确保交通安全的前提下，关闭无效照明，达到节能的目的。与道路照明不同的是，景观照明注重的是对环境的美化效果，为了及时确保景观与照明系统中间的协调性，可应用 LED 照明给人们带来更好的视觉享受。咸阳市现有路灯个数将近 70000 盏，管理范围广、难度大，但是，在路灯监控过程中，现有监控系统无法达到全市路灯同一时间开启（据调查，第一条街和最后一条街相差将近 20 分钟）；在特殊天气下，不能实现智能化自动切换到光控模式中，碰到特殊情况几乎全部靠人工进行控制，费时费力，又不易控制。该项目的研究成果可以直接应用到路灯监控自动化控制，代替人工操作，经济且成本低。因此，该项目的研究成果具有较好的应用价值和科学价值。

（3）同行引用评价

新系统是以日常路灯管控系统平台为依托，以高效、强大的空间数据库和知识数据库为支持，借助于GIS和ZigBee、无线物联网等技术手段，实现了基于网络化、可视化、智能化的实时开放式环境，集信息采集、反馈、控制、自定切换（时控与光控）、联动调度等功能于一体，形成可靠、便捷、自动调控的路灯节能管控系统平台。较好的实现了路灯的管控，节省了人力物力、提高了管理水平。

三、项目详细内容

1．立项背景

无线路灯管控系统是一个分散式控制和集中式管理的数据采集系统，集计算机技术、现代信息技术和系统控制于一体的高科技系统，利用计算机编程和借助特定通信方式，可以对路灯等照明设施的工作状态、环境信息等实施监控的控制系统。ZigBee 网络带宽较小，网络传输延时小以及功耗比较低。另外，ZigBee 技术是一种可以与传感技术相结合，应用简单，面向控制的无线传输技术，因为 ZigBee 技术传输带宽比较小，所以通信效率比较高，安全性好。ZigBee 技术的优点还可以和传感器完美的结合，因此，就目前而言，由于 ZigBee 无线技术的高效，低功耗的特点越来越多得到关注。ZigBee 技术是随着工业自动化对于无线通信和数据传输的需求而产生的一种新兴的近距离、低复杂度、低功耗、低数据速率、低成本的双向通信技术，主要适用于自动控制和远程控制领域，可以嵌入到各种设备中，同时还具有地理定位功能。

（1）立项的目的

经济意义：国内很对城市仍然采用的是配电箱分散管理，人工巡视的方式，管理和维护的效率低、成本较高。利用 ZigBee 技术与各种新型传感器、功率控制器相结合，可以实现路灯智能控制，达到节约能源，方便管理的目的。另一方面从源头上减少能源消耗，降低资源和管理运行成本。综合来说提高了经济效益。

学术意义：扩展 ZigBee 技术的应用范围，通过仿真设计研究 ZigBee 网络拓扑结构和路由协议，从理论上证明研究的可行性。

社会意义：系统自动化实时监测照明终端设备运行状态，能在第一时间内通过多种方式将故障信息告知工作人员，确保工作人员能及时掌握路灯运行信息，对突发事件及时处理，保障了道路照明系统稳健运行。有利于减少对照明管理部门的投诉，降低交通事故率，提高市民生活质量，维护文明城市形象，有很大的社会意义和现实意义。

（2）待解决的问题

本系统的关键在于改变以往我省路灯监控系统信号输出延缓问题（据调查，在信号同时输出情况下，第一条街和最后一条街亮灯时间相差将近 20 分钟）和特殊天气时控和光控的自动切换状态（在特殊天气下不能实现智能化切换到光控模式中），改善现行的监控系统实现自动化、可视化、智能控制，节省人力，并且一套系统可以适用于我省各县区，经济成本低，易于操作，可广泛推广。

3．科学技术内容

（1）项目研究的总体思路和目标

路灯管控系统是以 Linux 操作系统平台为基础，MSDE 数据库为核心，以路灯监控和管理应用软件为工具，GPRS/CDMA/GSM 或其他传输方式为远程数据通信网络，集监视、控制、管理功能为一体的一个分布型网络结构的计算机监控和管理系统。本系统集成 ZigBee 技术和无线物联网技术，针对其路灯管控平台实现了以下功能：

① 系统同时可以进行回路控制和单灯控制。

② 可测量单灯或回路的电压、电流、功率等因素。

③ 单灯终端盒和回路终端盒独立运行，现场控制，可以提高开关灯的可靠性。

④ 可在现场或通过监控中心设置单杆调光率或回路调光率。

⑤ 具备通过视频和负荷监控实现指挥及维修调度功能，可联动对应的管理摄像机。

⑥ 详细记录开关灯时间，方便节能量计算。

⑦ 控制系统失效时，能无条件保障照明。

⑧ 对白天意外亮灯、晚上意外熄灯、远程控制器故障、配电箱门开关不正常，电压电流超限和供电线路停电可报警。

⑨ 软件能进行节能量分析并提供相关报表。

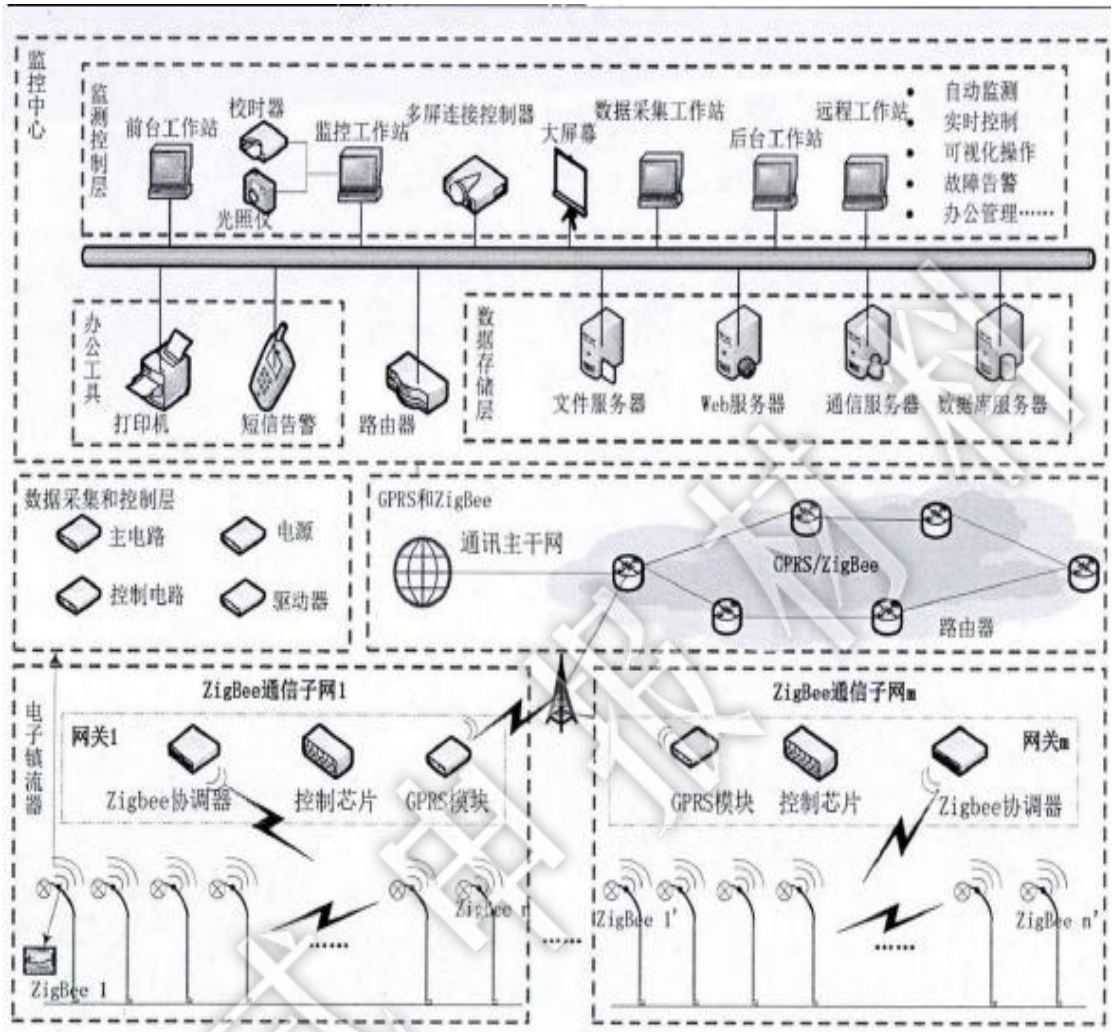
⑩ 监测道路车流量的功能的扩展接口。

该系统主要目标是依托于日常路灯管控系统平台为依托，以高效、强大的空间数据库和知识数据库为支持，借助现代化的ZigBee、无线物联网等技术手段，建立基于网络化、可视化、智能的实时开放式环境，集信息采集、反馈、控制、自定切换（时控与光控）、联动调度等功能化于一体，形成可靠、便捷、自动调控的路灯节能管控系统平台。

（2）项目研究的技术方案

本项目针对多路段大功率城市照明监控管理设计和开发，在满足高质量照明需求的同时，实现节能降耗的目的，同时具有远程控制、自动监测、故障告警及办公管理的功能，便怒人性化管理控制以及路灯故障的发现和定位。如图 1 所示为基于 ZigBee 技术的物联网城市照明管理硬件架构图，系统硬件架构主要分为三层，底层是数据采集和控制层，中间层为网络通信层，上层为系统监控中心，构成了分布式无线遥测、遥心、遥控的自动化“三遥”功能，实现对路灯系统的遥测变量参数、

遥信设备状态信息、遥控路灯启/闭。



系统运用集成化的思想采用 B/S 和 C/S 架构混合开发的模式，B/S 端为监控中心 Web 操作端，C/S 端为下位机底层监听端。系统通过 B/S 和 C/S 端软件并行开发，达到了缩短开发周期和提高系统运行效率的目的。C/S 模式的下位机监听软件，采用多线程开发语言进行处理操作，能够同时处理下位机端发来的数据和上位机下达的命令，提高了系统运行效率。B/S 端软件提供不同功能接口和业务模块显示数据库中的数据，在请求处理方面通过 Ajax 调用后台程序，后台程序获取数据库中的信息参数再传回来。Web 端软件和下位机监听软件中分别采用了成熟的开源框架，两款软件中的数据交互通过对数据库中的共用数据达到了同步的效果。下表为系统开发环境：

类别	硬件环境	软件环境
监控中心软件	计算机型号：LENOVO Y460	操作系统：Win7
	CPU：Inter（R）Core （TM）i5	开发工具：MVS2008
	内存容量：4.00GB	开发语言：JavaScript、C#
	硬盘容量：300GB	数据库：SQL Server2008
	计算机型号：LENOVO Y460	运行环境：.NETFramework
	CPU：Inter（R）Core （TM）i5	
	内存容量：4.00GB	
	硬盘容量：500GB	
监听软件	计算机型号：LENOVO Y460	操作系统：Win7
	处理器：Inter（R）Core （TM）i3	开发工具：Borland Delphi 7.0
	内存：2GB	开发语言：Delphi
	硬盘：500GB	数据库：SQL Server2008

（3）实施效果

新系统投入使用一年半以来主要改善了以下问题：

（1）以往我市路灯监控系统信号输出延缓问题(原系统在信号同时输出情况下，第一条街和最后一条街亮灯时间相差将近20分钟)和特殊天气时控和光控的自动切换问题(原系统在特殊天气下不能实现智能化切换到光控模式中)。

（2）提高亮灯率：系统投入运行后可以随时发现路灯运行中出现的问题，随时处理，提高亮灯

率。

（3）延长灯具寿命：采用路灯智能控制的情况下。据测试，正常电压（220V）情况下，钠灯电压为100V，电压升高后（230V-240V），钠灯电压可升至120V-150V；正常电压环境下降压节能运行后，钠灯电压一般为85V，电压升高环境下，钠灯电压可保持在100V左右。从理论和实际使用环境，采用调压控制节能可以延长路灯使用寿命。

（4）节约人力、物力，提高了管理水平：可实时监控每盏路灯、每个路段及亮化工程点工作状态，计算机可以及时对故障进行汇总，写入数据库，以便次日进行维修；利用动态实时模拟显示屏，监视全区路灯，值班员在中央控制室就可以概览路灯现场运行情况，从而减少了巡灯的维护成本和减轻了巡检人员工作强度，大大提高工作效率。另外，在恶劣天气时，根据各路灯控制智能终端采集的数据情况加以分析，采取相应紧急措施，避免了交通事故的发生。

（5）直接经济方面：投入使用新系统后，可在深夜行人稀少和交通量减少的情况下，执行“隔二亮一”的照明方式，既给夜间出行的行人带来了便利又节约了大量的电费支出。在实现单控方面，达到节能 5%以上。

4．本研究的发现点、发明点和创新点

该项目的主要研究成果是以日常路灯管控系统平台为依托，以高效、强大的空间数据库和知识数据库为支持，借助现代化的ZigBee、无线物联网等技术手段，建立基于网络化、可视化、智能化的实时开放式环境，集信息采集、反馈、控制、自定切换（时控与光控）、联动调度等功能于一体，形成可靠、便捷、自动调控的路灯节能管控系统平台。

本项目的关键在于改变以往我省路灯监控系统信号输出延缓问题（据调查，在信号同时输出情况下，第一条街和最后一条街亮灯时间相差将近 20 分钟）和特殊天气时控和光控的自动切换状态（在特殊天气下不能实现智能化切换到光控模式中），改善现行的监控系统实现自动化、可视化、智能控制，节省人力，并且一套系统可以适用于我省各县区，经济成本低，易于操作，可广泛推广。

该项目的特色与创新之处：

（1）集成式研究---在基础路灯管理技术系统平台的基础上进行 Zigbee 技术和无线物联网技术的集成；

（2）项目的创新点在于改变以往咸阳市路灯监控系统信号输出延缓问题和特殊天气时控和光控的自动切换现状，改善现行的监控系统实现自动化可视化智能控制，节省人力，并且一套系统可以适用于咸阳各县区，经济成本低，易于操作，可广泛推广；

（3）该项目的先进性。本项目的先进性在于包括遥控、数据采集、无线通信、自动控制、地理信息以及信息管理等，及一套完整的系统，而该系统又是更复杂系统的基础，因此还可以推广到类似的项目，如城市污染管理、楼宇自动化监控、自来水供水控制、城市供电控制管理以及其它类似领域。

5.与当前国内外同类学科技术研究现状与水平比较

在国外,很多国家已经使用计算机系统来进行对路灯的照明系统的控制和管理监控。比如法国、新加坡、德国等国家，就是通过一个电脑实现自动化的控制管理，配合当天的日出日落情况节省能源。在这些国家当中，就属以色列的耶路撒冷的监控系统最为典型。它的路灯管理信息传输方式利用了 GSM、超短波两种信道自由切换，在当地城市建立一些地理信息中心站、监控站和遥测终端等设备。在这些设备的帮助下，实现了对路灯供电系统故障进行自动排查的功能，根据情况自动调节路灯供电系统功率来达到合理节能使用路灯的目的。另外，现在的欧洲尤里卡计划项目之一就是对路灯电子镇流器和路灯远程监控系统的研发和设计。这个系统可以对每一个单灯进行控制和信息的传输。这些是目前国外的路灯监控系统的一些情况。

近些年随着全球人口和经济规模的不断增长，能源短缺和环境污染问题日益严重。“低碳经济”逐渐成为各国的共识。照明又是城市中的能耗大户，因此照明节能问题很早就引起了很多国家特别是发达国家的重视，也尝试了各种方案。城市路灯照明是城市基础设施的组成部分，首先要考虑到交通安全问题，同时又要符合节能减排的要求，这就对城市路灯智能化控制提出了更高的要求。目前常见的太阳能照明系统主要有一下几种的应用形式：

（1）结合运动探测器等设备对不同地理位置的照明灯进行自动开启和关闭的控制。

（2）结合调光和灯光亮度探测等设备，能够自动调节灯光的亮度，使得灯光亮度随着日照等外界环境的影响而进行自动调节，使整个空间的照度保持在一个稳定的范围。

（3）配合遥控装置，使得人们不需要移动位置就可以对各个方位的灯具进行控制。

（4）能够通过系统的定时单元，实现对灯具的定时操作。

然而这些传统的路灯照明监控实现以上功能就存在了人力资源浪费大，灯具使用寿命短，无法远程控制，不能自动开关盒调光，人工作业量大灯缺点，而且由于控制器对于蓄电池的保护不充分而导致蓄电池很容易损坏。

现在的照明系统已经朝着设备微型化、控制集成智能化、无线网络化、节能环保化的方向发展。在国内利用计算机技术控制照明已经是主流技术。ZigBee 技术已经比较成熟，但是在国外还没有真正广泛应用在路灯智能控制上，在我国路灯智能化起步较晚，目前还处于初级阶段。针对目前市场上的大多数太阳能路灯都是一盏盏鼓励的路灯，普遍存在着效率不高，可靠性不高，管理困难，损坏或出现故障未能及时报修等问题。利用 ZigBee 技术与 LED 路灯的结合能很好的解决路灯的这些问题。因为对于智能路灯照明系统这种通信的距离有限，传输的数据容量较小，只需要低的数据传输速率，要求能实时传送信息，并且这些嵌入式终端设备只需要电池供电的要求，正是 ZigBee 技术的便宜、低功耗、低传输速率的特点相对应，而且 Zigbee 节点通过传感器采集周围环

境的信息并通过无线自组织网络汇聚到中心节点，正适用于路灯控制这种分散式检测、集中式管理的应用场合。

5．应用情况（经济效益、社会效益情况）

科学技术越来越发达，在我们建设智慧城市的步伐中，国内众多的高科技智能产品在全国各大城市广泛的应用，对于路灯照明行业同样如此。在智慧城市建设中，智慧路灯顺应了如今社会信息时代的智慧产品，在提升照明的人性化同时提升了行人舒适度以及智能化为出发点，集合LED照明。信息化的管理模式如，采集，传输，以及信息发布，数据处理和控制执行等多种物联网技术，通过密集的城市路灯设备，构建成高效的公共管理网络。

随着照明路灯技术的不断发展和技术不断创新，路灯的潜力价值不断深挖，智慧路灯的出现使得路灯路灯管控方式变得高效节能了。与此同时，我国“智慧城市”建设快速发展，很多业内人士意识到通过智慧路灯搭载多功能模块，可以为人们生活提供便捷服务。同时对于智慧路灯市场发展空间有了很大广阔的市场前景。

该研究经过对陕西省咸阳市路灯状态的调研，获知了咸阳市近 70000 万盏路灯的分布状态，通过对咸阳市路灯照明监控系统说明书的仔细阅读和对系统的运行情况的实地分析考查，获知该系统采用时控的控制方案，主站自动遥控全市的全夜灯、半夜灯和景观灯的开关和关灯。操作前台机的软件界面，可以设置和修改开关灯的光控照度值。系统可以根据不同类型的灯光控制要求，把全部灯光设备分成若干个组，进行实现群控和组控，在特殊情况下可以按照运行软件的提示，运用前台机的软件按钮，手动对全夜灯和景观灯进行遥控开/关操作。且我市路灯近几年在维护方面一直采用的是配电箱分散管理,人工巡视的方式,管理和维护的效率低、成本较高。

新系统是以日常路灯管控系统平台为依托，以高效、强大的空间数据库和知识数据库为支持，借助于GIS和ZigBee、无线物联网等技术手段，实现了基于网络化、可视化、智能化的实时开放式环境，集信息采集、反馈、控制、自定切换（时控与光控）、联动调度等功能于一体，形成可靠、便捷、自动调控的路灯节能管控系统平台。新系统投入使用一年以来主要改善了以下问题：

（1）以往陕西省咸阳市路灯监控系统信号输出延缓问题(原系统在信号同时输出情况下，第一条街和最后一条街亮灯时间相差将近20分钟）和特殊天气时控和光控的自动切换问题(原系统在特殊天气下不能实现智能化切换到光控模式中)。

（2）提高亮灯率：系统投入运行后可以随时发现路灯运行中出现的问题，随时处理，提高亮灯率。

（3）延长灯具寿命：采用路灯智能控制的情况下。据测试，正常电压（220V）情况下，钠灯电压为100V，电压升高后（230V-240V），钠灯电压可升至120V-150V；正常电压环境下降压节能运行后，钠灯电压一般为85V，电压升高环境下，钠灯电压可保持在100V左右。从理论和实际使用环境，采用调压控制节能可以延长路灯使用寿命。

（4）节约人力、物力，提高了管理水平：可实时监控每盏路灯、每个路段及亮化工程点工作状态，计算机可以及时对故障进行汇总，写入数据库，以便次日进行维修；利用动态实时模拟显示屏，监视全区路灯，值班员在中央控制室就可以概览路灯现场运行情况，从而减少了巡灯的维护成本和减轻了巡检人员工作强度，大大提高工作效率。另外，在恶劣天气时，根据各路灯控制智能终端采集的数据情况加以分析，采取相应紧急措施，避免了交通事故的发生。

（5）直接经济方面：投入使用新系统后，可在深夜行人稀少和交通量减少的情况下，执行“隔二亮一”的照明方式，既给夜间出行的行人带来了便利又节约了大量的电费支出。在实现单控方面，达到节能 5%以上。该系统实现对路灯的数字化监控管理，为城市照明节省大量的人力物力；系统采用照明区域化管理，有利于统一协调，扩大管理范围，降低管理成本，提高照明管理水平；实现对路灯监控报警，可缩短抢修周期降低维修费用，照明亮度和亮度策略的动态控制，节约照明能源，避免不必要的照明浪费。

（6）作为比较完整的计算机控制项目。本课题设计包括遥控、数据采集、无线通信、自动控制、地理信息以及信息管理等，及一套完整的系统，而该系统又是更复杂系统的基础，因此还可以推广到类似的项目，如城市污染管理、楼宇自动化监控、自来水供水控制、城市供电控制管理以及其它类似领域，可以说，研究城市路灯监控系统会对今后开展其它工作和项目具有非常重要的指导意义。

综上所述，随着城市照明数字化智能管理系统的逐渐成熟，其发展前景不可估量，不仅提升了城市的照明效果，还充分体现了节能减排的理念，并且在物联网的基础上，将整个城市覆盖在现代化的通信设备与通信网络当中，向感知型现代化城市迈进。

6．申请、获得知识产权情况				
国别	知识产权类别	成果名称	申请号	授权号（批准号）
中国	发明专利	一种路灯信号控制方法		ZL201610219267.9
中国	实用新型	一种基于 GIS 的路灯照明控制系统		ZL201520655287.1
中国	实用新型	一种基于 ZigBee 的无线路灯管控系统		ZL201620278752.9
中国	计算机软件著作权	基于 51 单片机的路灯故障实时检测管理系统 V1.0	2017SR676432	2261716
中国	计算机软件著作权	基于 GIS 的路灯照明监控系统 V1.0	2016SR181155	1359772
中国	计算机软件著作权	基于 ZigBee 技术的无线路灯照明监控系统 V1.0	2017SR676230	3361514

四、项目主要完成人员情况表

第 1 完成人：

姓　名	刘彦戎	性别	女	年龄	39
所在单位	陕西国际商贸学院		文化程度		硕士
从事专业	电子信息技术		技术职称		讲师
参加本项目的起止时间	2017-01-01 至 2018-12-31				
对项目的主要创造性贡献	在项目的开展过程中，根据项目设定目标，有效的规划项目组成员的任务和职责，及时了解项目组成员的工作进度，并快速解决项目组成员遇到的各个问题。在项目的框架设计方面，查阅各种资料以确定项目的框架符合系统开发的要求，更有效，更简洁、适用性更强的原则进行主流框架的选择，之后对于系统平台进行有效测试，分别从功能测试和模块测试等方面对软件平台进行测试，并结合咸阳市路灯管理处的资源，在渭城区 3 条街道进行实地应用，很大程度上改善了咸阳市路灯管理系统的现有故障问题。				
声　明	本人严格按照《陕西高等学校科学技术奖励办法》的具体要求，对推荐书及其附件进行了审阅，确认全部内容和材料属实，并符合相关保密规定。如有不符，本人愿意承担相应后果并接受相应处理。 本人签名：_____ 年　　月　　日				

第 2 完成人：

姓　名	商莹	性别	女	年龄	39
所在单位	陕西国际商贸学院		文化程度	硕士	
从事专业	电子信息技术		技术职称	副教授	
参加本项目的起止时间	2017-01-01 至 2018-12-31				
对项目的主要创造性贡献	在本项目开展过程中主要负责通过网络调研、市场调研等方式对项目进行了调研工作，分析了项目的可行性，并对项目系统进行了全面分析，通过分析了解掌握了各组成部分的功能及具体要求，并结合功能需求进行了硬件系统的设计，进行了硬件系统的测试工作。				
声　明	本人严格按照《陕西高等学校科学技术奖励办法》的具体要求，对推荐书及其附件进行了审阅，确认全部内容和材料属实，并符合相关保密规定。如有不符，本人愿意承担相应后果并接受相应处理。 本人签名：_____ 年　　月　　日				

第 3 完成人：

姓　名	王丽君	性别	女	年龄	37
所在单位	陕西国际商贸学院		文化程度	硕士	
从事专业	物联网通信技术		技术职称	高级工程师	
参加本项目的起止时间	2017-01-01 至 2018-12-31				
对项目的主要创造性贡献	在项目的开展过程中主要负责检验传感器的特性和传感器的主要功能模块，针对此系统，结合传感器的工作状态，对由传感器组成的系统进行功能测试，调试过程中若出现故障，寻找出现故障的原因，及时解决。实测过程中记录各种实验数据，为本研究的成果奠定基础。				
声　明	本人严格按照《陕西高等学校科学技术奖励办法》的具体要求，对推荐书及其附件进行了审阅，确认全部内容和材料属实，并符合相关保密规定。如有不符，本人愿意承担相应后果并接受相应处理。 本人签名：_____ 年　　月　　日				

第 4 完成人：

姓　名	刘斌	性别	男	年龄	47
所在单位	陕西科技大学		文化程度		
从事专业	计算机科学		技术职称		副教授
参加本项目的起止时间	2017-01-01 至 2018-12-31				
对项目的主要创造性贡献	在本项目的开展过程中主要负责软件项目的详细设计、编码和内部测试的组织实施，对该软件项目兼任系统分析工作，完成分配项目的实施和技术支持工作。并参与需求调研、项目可行性分析、技术可行性分析和需求分析等工作。				
声　明	本人严格按照《陕西高等学校科学技术奖励办法》的具体要求，对推荐书及其附件进行了审阅，确认全部内容和材料属实，并符合相关保密规定。如有不符，本人愿意承担相应后果并接受相应处理。 本人签名：_____ 年　月　日				

五、附件目录

附件大类	子类	序号	附件名称
五、其他证明	其他证明	1	立项和结题报告
五、其他证明	其他证明	2	咸阳市科技局结题证明
一、论文著作证明	主要论文著作	3	基于 ZigBee 技术的无线路灯基本管控系统研究
一、论文著作证明	主要论文著作	4	基于 GIS 的路灯节能管控系统研究
一、论文著作证明	主要论文著作	5	基于捕获和滤波的网络数据包分析技术研究--EI
一、论文著作证明	主要论文著作	6	基于多相多场耦合自适应传感器网络路由算法-EI
一、论文著作证明	主要论文著作	7	智慧城市智能管理系统
二、知识产权证明	发明专利	8	一种路灯信号控制方法
二、知识产权证明	实用新型	9	一种基于 GIS 的路灯照明控制系统
二、知识产权证明	实用新型	10	一种基于 Zigbee 的路灯监控系统
二、知识产权证明	计算机软件著作权	11	基于 51 单片机的路灯实时监控系统（软著）
二、知识产权证明	计算机软件著作权	12	基于 GIS 的路灯照明监控系统（软著）
二、知识产权证明	计算机软件著作权	13	基于 ZigBee 技术的无线路灯照明监控系统（软著）
三、应用证明	应用证明	14	企业应用证明

资助类别：面上项目

申请代码：F.信息科学-F02.计算机科学-F0205.计算机应用技术-F020509.人工智能应用

项目编号：2017JM6111

陕西省自然科学基础研究计划

项目任务书

项目名称：基于ZigBee技术的无线物联网路灯节能管控系统研究

承担单位：陕西国际商贸学院

项目负责人：刘彦戎

起止时间：2017-01-01至2018-12-31

填报日期：2017年06月21日

陕西省科学技术厅 制

六、签批审核表

我获受陕西省自然科学基础研究计划的资助，将按照申请书、项目批准意见和任务书负责实施本项目，严格遵守陕西省科技厅关于资助项目管理、财务等各项规定，切实保证研究工作时间，认真开展研究工作，按时报送有关材料，及时报告重大情况变动，对资助项目发表的论著和取得的研究成果按规定进行标注。 项目负责人（签章）：刘彦武 2017年7月10日	
我单位同意承担陕西省自然科学基础研究计划项目，将保证项目负责人及其研究队伍的稳定和研究项目实施所需的条件，严格遵守陕西省科技厅有关资助项目管理、财务等各项规定，并督促实施。 承担单位（公章）： 2017年7月10日	
合作研究单位1（盖章）： 2017年7月9日	合作研究单位2（盖章）： 年 月 日
科技厅审查意见	业务处室负责人（签章）： 业务处室经办人：张岩实　　电话：81294815 通讯地址：陕西省西安市丈八五路10号陕西省科技资源统筹中心 邮编：710077 陕西省科学技术厅（盖章）： 年 月 日 2017年9月08日

陕西省自然科学基础研究计划项目
结题审查结果的通知

刘彦戎先生/女士：

你所承担的陕西省自然科学基础研究计划项目结题材料已收悉。按照陕西省自然科学基础研究计划结题项目评价指标和有关规定，经审查，符合结题要求，同意结题。

项目名称：基于ZigBee技术的无线物联网路灯节能管控系统研究

项目编号：2017JM6111

评价结果：验收通过

特此通知。

项目管理负责人（签章）：

项目管理经办人（签章）：

陕西省科技厅项目验收审核意见及验收专用章

2019年07月09日

收件记录	
日期	
收件人	

项目类别		
	1、农业项目	□
	2、工业项目	☑
	3、社会发展项目	□

咸阳市科技计划项目
结题报告

项目编号：2015KT-08

项目名称：基于GIS可视化的咸阳市路灯监控系统开发

项目负责人：刘彦戎

承担单位：陕西国际商贸学院

资助资金：2.0万元

计划完成时间：2015年12月-2017年12月

实际完成时间：2018年5月

联系电话：13619100933

咸阳市科学技术局

二〇一八年一月制

课题组意见：

本项目采用基于可视化的GIS技术和Zigbee技术相结合的方法对咸阳市的现有管理系统进行的优化升级和主要监控模块的增加研究，该过程所涉及的研究方法客观、较科学，符合现行的无线管理技术，具有创新性，较好的完成了课题任务。最终较好的解决了对咸阳市现有路灯管理系统的优化和在仿真实验中的较好解决了现有路灯管理系统信号输出迟缓和不能实现智能切换状态的控制模式。对咸阳市的城市亮化将得到较好的改善。

负责人（盖章）

2018年5月10日

所在单位审核意见：

该项目能够立足于咸阳市现有路灯管控系统存在的问题进行理论和实践的研究，为改善咸阳市路灯管控系统提供技术参考，产生有一定的经济和社会效益。该过程所涉及的技术路线合理、科学，经费计算合理，研究人员和研究条件具备。按照课题结题要求顺利完成任务。

（单位公章）

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论文收录引用检索报告

检索项目	检索陕西国际商贸学院刘彦戎(YANRONG Liu) 2018 年发表的论文被 SCI(Science Citation Index) 网络数据库收录情况。
检索工具	Web of Science Science Citation Index Expanded (SCI-EXPANDED) 网络版（1975 年至今）
检索方式	题目（作者提供文章列表）
检索结果	详见附件（共计 1 份 1 页）
检索结论	检索陕西国际商贸学院刘彦戎(YANRONG Liu) 2018 年发表的论文被 SCI(Science Citation Index)网络数据库收录情况： 共有 1 篇被 SCI 收录。详情见附件。

特此证明。

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附件一：论文被 SCI 检索详细情况

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摘要: With the deepening of China's reform and opening up, the number of cities and the size of cities are increasing, and the urban infrastructures are also constantly improved. Among them, one of the most typical infrastructures is urban street lamp. However, the power consumption of traditional street lamps is large, and it is difficult to realize the intelligent adjustment and control with the change of the use demands. The Zigbee wireless communication technology was specifically applied to the urban street lamp monitoring system, so as to effectively reduce the power consumption of street lamps and realize the intelligent control of street lamps. According to the simulation experiment of the system, it can be seen that the system has excellent performance, remarkable energy saving effect and good application value.

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Article:

Energy Saving and Monitoring System for Urban Street Lamps Based on Zigbee Wireless Communication Technology

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Abstract

With the deepening of China's reform and opening up, the number of cities and the size of cities are increasing, and the urban infrastructures are also constantly improved. Among them, one of the most typical infrastructures is urban street lamp. However, the power consumption of traditional street lamps is large, and it is difficult to realize the intelligent adjustment and control with the change of the use demands. The Zigbee wireless communication technology was specifically applied to the urban street lamp monitoring system, so as to effectively reduce the power consumption of street lamps and realize the intelligent control of street lamps. According to the simulation experiment of the system, it can be seen that the system has excellent performance, remarkable energy saving effect and good application value.

Keywords

Zigbee, Wireless Communication, Street Lamp, Monitoring System

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Introduction

With the continuous progress of urbanization in China, urban infrastructure construction has become an important component of urban development. Street lamps play an important role in people's production, life, traffic, public security and so on [1]. From a certain point of view, the level of management and control of the street lamp can reflect the degree of civilization of the city to a certain extent [2]. With the development of modern communication technology and the promotion of information technology, the street lamp monitoring system in major cities of China has achieved a high degree of automation. With the increasing population of our country, the population and scale of cities are also increasing, and the problems of energy consumption and environmental pollution are becoming increasingly prominent. The traditional street lamp monitoring system has the shortcoming of low power utilization, which becomes an urgent problem to be solved in urban development [3]. The lamps and lanterns of traditional city lighting in our country mostly adopt lamps such as metal halide lamp and incandescent lamp with high energy-consumption. The lamps and lanterns not only have low luminous efficiency, but also have short service life. The street lamp monitoring system is not intelligent enough. Whether it is the switch operation of the street lamp or the brightness adjustment of the street lamp, it is difficult to realize the intelligent regulation and control [4]. At the same time, China has no perfect street comprehensive monitoring system to the street lamps constructed, so it is difficult to keep abreast of the current, voltage and power of the street lamps. Judging the running state of the street lamp is still in a relatively backward level [5]. Therefore, it is necessary to use the modern information technology to design urban street lamp energy saving and monitoring system, so as to

improve energy-saving lamps city efficiency, realize intelligent monitoring supervision and promote the development and construction of "smart city".

State of the Art

Street lamp monitoring system realizes automatic control and communication, so as to realize the intelligent monitoring and management of street lamps based on integrated technologies of modern information technology and computer technology by using remote monitoring system and distributed data acquisition [6]. As early as 1990s, foreign countries have begun to carry out intelligent lighting system research and successfully developed a fairly intelligent lighting intelligent control management system. Among them, the Panasonic home bus system and the Swiss I-Bus bus are typical representatives. These systems have achieved good results in practical applications, and have gradually been widely used [7]. With the continuous development of modern wireless communication technology, the traditional wired transmission has been gradually replaced by wireless. The new wireless intelligent light control system has better advantages. It not only has lower cost, but also has very good adaptability, and it is easy to install and flexible [8]. From the aspect of data transmission, the development of street lamp monitoring system in our country can be divided into four stages: (1) the first stage is the end of the 1980s. The control of street lamps basically adopted the 220V strong electricity to carry on the wired transmission; (2) the second stage is from the early to the middle of twentieth Century 90s. This stage was controlled by telephone lines and power lines; (3) the third stage is from the middle to the end of 1990s. At this stage, 230MHz special channel was used to realize wireless data transmission; (4) the fourth stage is from twenty-first Century to date. Based on the GPRS/CDMA communication mode provided by China Telecom, mobile and China Unicom, the wireless network data transmission is carried out [9].

Methodology

System Networking and Routing Scheme Design

The design of street lamp wireless monitoring system is achieved based on Zigbee network. The street lamp control terminal and the street lamp monitoring sub-station have to assemble a network to achieve effective and regular communication. There are two steps to build a network by using Zigbee. Firstly, a Zigbee network is constructed by using coordinator; secondly, other routing nodes can be added to the network according to the coordinator's permission. If each node wants to successfully establish a Zigbee network, it must be required that the node is a FFD device and concurrently has the Zigbee coordinator capability. The node can't connect with other networks. If it has been connected to other networks, the node can only become sub-node of the network.

When the coordinator builds the network, it needs to confirm the coordinator firstly. If the node is a FFD device, it needs to be further judged whether or not it has joined another network. A beacon frame is transmitted via an active scan. If the beacon is not monitored within the given scan period, the FFD device can be used as a coordinator to form a new Zigbee network. On this basis, a beacon frame is continuously broadcast [10]. After the confirmation of the coordinator, channel scanning is necessary. Scanning can be done by using two ways of active scanning and energy scanning. In order to avoid possible disturbances, the coordinator first performs the channel energy detection, while the energy is used to sort the channels in an incremental fashion. If the detected energy value exceeds the allowable energy level, the channel is determined to be unavailable and should be discarded. Otherwise, it may be marked as an available channel [11]. After completing the active scan, a relatively quiet and less Zigbee device channel is selected in the scan results.

When the channel value is selected, the coordinator selects a PAN ID for the network. This identifier is unique in the channel, and its range is ≤0x3FFF. In the street lamp monitoring system, the network group identifier is considered as group number of Zigbee network. In addition, there are 16-bit short address and 64-bit extended address in these networks [12]. The short address is assigned by the coordinator, and the extended address is determined by IEEE. The short address is used in the street lamp monitoring system. In the same Zigbee network, short address is unique. If a new node is added to the network, the short addresses are assigned by the parent

node. Upon completion of the coordinator network, the routing node can be added to the network. When the parent node is successfully selected and it becomes its child node, a short address can be obtained at the parent node. The source node is able to know the destination node of the data transmission through this short address. The specific process of routing nodes to the network is shown in Figure.1.

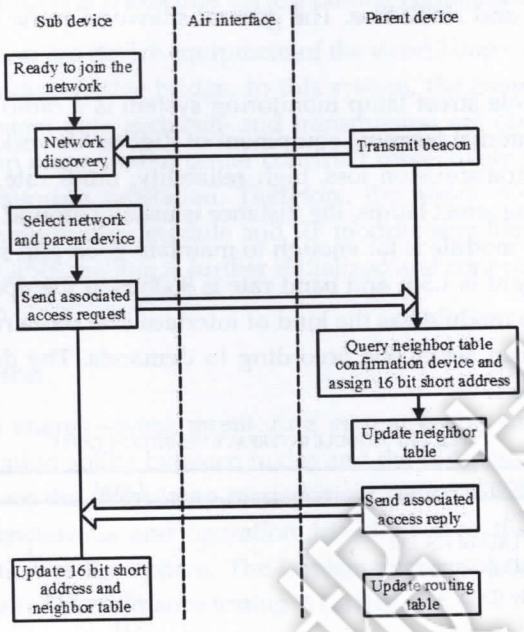

FIG. 1 THE FLOW CHART OF ROUTING NODES ADDED TO THE NETWORK

The new routing node has to join the current network. On the basis of confirming that the node is not joined to other nodes, the surrounding parent device nodes are actively scanned. When the routing node scans the beacon on the channel, the relevant information in the neighbor's table can be recorded. If a node wants to leave the network, it is first necessary to send a request to terminate the relationship to the parent node of the child node. When the parent node receives the request and succeeds in processing it, it sends an association response to the child node. The child node can leave the network after receiving it.

3.2 System Hardware Design

In the street lamp wireless monitoring system, each street lamp is regarded as a basic unit and each road lamp post is provided with a street lamp control module. The unit module can monitor the running status of each street lamp in real time, and execute the commands issued by the user effectively, so that the wireless communication of the street lamp can be better carried out. The hardware components of the street lamp control terminal are LED street lamp driving control unit, voltage and current information monitoring unit, and RF module unit and power module. The specific hardware structure is shown in Figure.2.

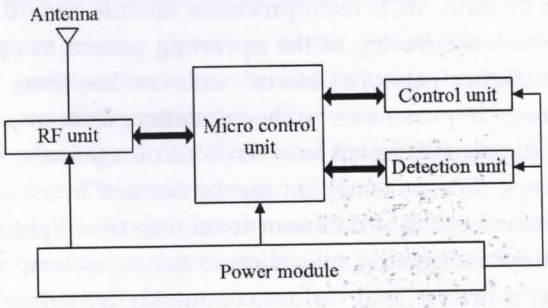

FIG. 2 HARDWARE STRUCTURE DIAGRAM OF STREET LAMP CONTROL TERMINAL

Only the MCU microcontroller has enough storage space can it better communicate with the RF module, process and store data packets, and it is the terminal device CPU of the whole street control system. In addition, it also has very powerful data processing capabilities, thus taking the ARM Cortex-M3 kernel 32 bit microcontroller. It has storage space for 20kRAM and 128kROM. Storage space is large and the maximum clock speed can reach 72MHz. There are 9 communication interfaces, 51 I/O ports and 7 timers. At the same time, it also has the characteristics of low power consumption, low cost and small size. The general silkworm pupa is powered by 3.3V and supports DMA controller with 7 channels.

The wireless transceiver of the whole street lamp monitoring system is a radio frequency unit. It can realize the wireless data transmission of the internal terminal equipment of Zigbee network. It has many advantages, such as long transmission distance, small transmission loss, high reliability, multi rate, intelligent data control and low power consumption. When installing street lamps, the distance is usually around 30m. It is necessary to ensure that the transmission distance of the RF module is far enough to maintain good and stable communication between the street lights. When the antenna height is 1.5m and baud rate is 960bps in the open area, the transmission distance of 600m can be achieved. The video module has the kind of interface that contains the three TTL, RS232 and RS485 interfaces. When in use, the user can select one according to demands. The definition tables of these three RF module interface are shown in Table 1.

TABLE 1 RF MODULE INTERFACE DEFINITION TABLE

Interface name	Function description	Level	Remarks
GND	Power ground		
A(TXD)	RS-485 A or TXD of RS-232		
B(TXD)	RS-485 B or RXD of RS-232		
VCC	Power supply (DC)	+3V～+5.5V	
SLEEP	Sleep control	TTL	Active low level
TEST	Internal testing		
DGND	Signal ground		
RXD/TTL	Data reception	TTL	
TXD/TTL	Data emission	TTL	

The street lamps select LED street lamps. Compared with the traditional high-pressure sodium lamp, the LED street lamp driving control unit has the advantages of high luminous efficiency, energy saving, long life, green environment and safe as well as reliable. The LED street lamp control panel is used for LED lamp switch control. And the RS485 protocol is used to communicate effectively between the LED driver control panel and the moderate NMCU. The traditional street lamp uses the electron light field radiation luminescent, so the filament is easy to burn out and easy to form the light attenuation. Because of the encapsulation of epoxy resin, LED light lamp can withstand higher mechanical shock and vibration. It is not easily broken and the average life reaches more than 100 thousand hours, which can greatly reduce its maintenance costs. LED street lamps do not contain harmful metals such as mercury, and do not produce harmful substances when they are scrapped.

System Software Design

The software layer of wireless sensor network can be divided into three layers: hardware abstraction layer, application layer and system service layer. The hardware abstraction layer of the system shows power module with upper shield, data acquisition module, MCU microprocessor module and other hardware details. The system service layer mainly performs the task scheduling of the operating system, supports the transport protocol and implements the routing algorithm. Zigbee network data transmission has three ways. The three approaches are from the control terminal of the street lamp monitors to the substation, from monitor substation to the street light control terminal, and peer to peer data transmission between control terminals of street lamps. According to the transmission direction of data stream, data transmission can be divided into submission and reporting. Among them, the reporting refers to the transmission of data sent from the street lighting control terminal to the street lamp monitoring substation, and from monitoring substation to the street lamp management center through the GPRS transmission. The submission is reverse, and various commands are sent to the street lamp control terminal from the street lamp management center and carried out.

Once the node is powered, initialization is performed. These operations include timers, serial ports, I/O buttons, and other initialization configurations. The initialization of the operating system is followed, thus allowing the system to enter an infinite loop state. In order to minimize node power loss, each stage is kept dormant at the time of initialization, which will take up less CPU resources. When the interrupt is generated, it triggers the task to be performed. CPU allocates resources for it and executes corresponding communication service subroutines.

The street lamp monitoring substation is a device equipment of the street lamp control terminal and the street lamp management center, and it is an indispensable bridge. In this system, the coordinator is used as the street lamp monitoring substation, and the system data exchange and transmission are carried out. Because the street lamp control terminal and the street lamp management center construct respectively the GPRS network and the Zigbee network with the street lamp monitoring substation. Therefore, the nodes of the station monitoring subsystem must be equipped with GPRS communication module and RF module simultaneously. When the initialization of the device MCU is completed, the GPRS module is further initialized and connected to the GPRS network based on the GPRS protocol.

Result Analysis and Discussion

The basic unit of the street lamp energy-saving monitoring system is the street lamp control terminal, which directly determines the communication ability between nodes and the communication performance of the system. The whole system management uses the street lamp management center to realize the man-machine interaction. Therefore, the function comprehensiveness and operation friendliness of the street lamp management center system directly affect the application of the system. The implementation of the street lamp management center interface functions and communication performance testing is carried out.

Firstly, the numbered code is used to download to the MCU in the street monitor substation, and vein relaxing serial debugging assistant is used to see whether the network is successful. The test of network serial port is shown in Figure.3. It can be seen from Figure.3 that coordinator builds network successfully, and sets up the network number. Each PAN identifier accounts for 2 bytes in size. The system allocates a 64-bit extended address and network address 0x0000 to the coordinator.

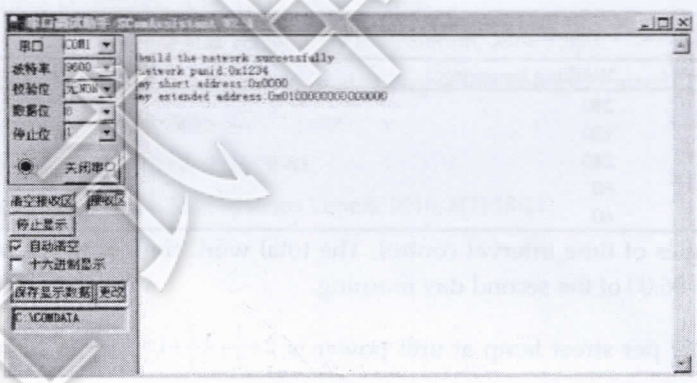

FIG. 3 SCHEMATIC DIAGRAM OF COORDINATOR SETTING UP NETWORK SERIAL PORT TEST

In order to verify the performance of routing algorithm in the system, simulation experiments are carried out by using NS2 software. The average packet delivery rate is used to judge the reliability of network data transmission. The simulation environment is as follows concretely. The communication distance is 15m, and the distance between nodes is 10m. The network range is 50 * 50m, and the packet size is 70Byte. The maximum number of nodes allowed by the parent node is 4. The maximum number of routers is 4, and the maximum network depth is 3. The simulation time is 5min. The specific simulation results are shown in Figure.4. It can be seen from Figure.4 that the system routing algorithm has a higher average packet delivery rate, which is at 99.5% up and down with very high reliability and availability basically.

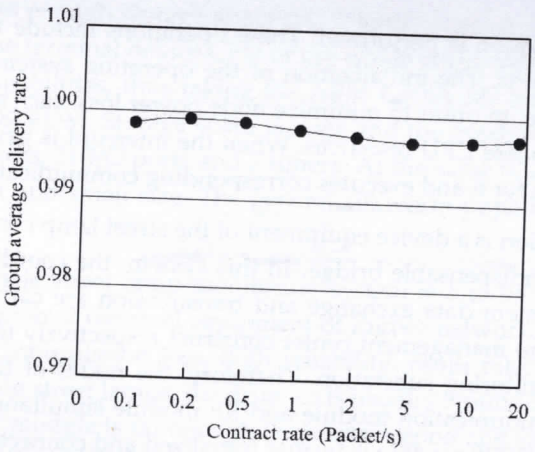

FIG. 4 GROUP AVERAGE DELIVERY RATE

Every function test of the street lamp management center is further carried out. Street of a coastal city is selected as a test point and a total of 16 street lighting nodes are arranged. The street lamp nodes are represented as U fonts, and the 16 nodes are considered as a group. It can be seen through the function test of the street lamp management center that the main functions can be obtained of the street lamp management center are as follows: (1) the street lamp control terminal can be controlled separately, and any street lamp node is operated on / off at the main interface of the management center. The corresponding street lamp node will be displayed as on / off state; (2) the status information of the street lamp node can be displayed in real-time, including the current, voltage and power of the node. A graph can be drawn based on this, so as to evaluate the operation of the node scientifically; (3) malfunction and burglar alarm function. When the situations that overvoltage, overcurrent and wire is cut occur, the street lamp management center sends out alarm information automatically.

The energy saving effect test of urban street lamp energy saving monitoring system based on Zigbee wireless communication technology is carried out. The opening / closing time of street lamps in different periods is controlled. The details are shown in Table 2.

TABLE 2 LIGHT MODE TIME DISTRIBUTION MAP

Working hours	Working hours(min)	Working model
18:00～22:00	240	All bright
22:00～24:00	120	1/2
0:00～04:00	240	1/3
04:00～05:00	60	1/2
05:00～06:00	60	All bright

Table 2 identifies the strategies of time interval control. The total work time of the street lights is 12 hours, from 18:00 of the first day noon to 06:00 of the second day morning.

Base on this, power saving of per street lamp at unit power is $2\times\frac{1}{2}+4\frac{2}{3}+1\times\frac{1}{2}=\frac{25}{6}$ W·h, and power consumption is $12-\frac{25}{6}=\frac{47}{6}$ W·h. As a result, the power consumption per street lamp is about 0.32 kW·h per day. If the traditional 125w rated high pressure sodium lamp is used, the power consumption of 12h working time is 1.5 kW·h. It can be seen through comparison that after adopting the street lamp wireless monitoring system, the power consumption can be saved by 1.18 kW·h per day, and the energy saving effect is obvious.

Conclusions

In order to reduce the increasing energy consumption of the street lamps with the city urbanization continuing to promote, and improve skill effectiveness and intelligent control of intelligent control of modern city street, the urban street lamp energy saving monitoring system based on Zigbee wireless communication technology was proposed. The system can realize data transmission and communication based on Zigbee wireless communication

and GPRS. Each street light control module is the basic unit of the street lamp wireless monitoring system. The communication data network is used to achieve the information monitoring of LED street lamp driving air cell, voltage and current. Wireless sensor network software is divided into three layers: hardware abstraction layer, application layer and system service layer. Among them, one of the most important is the street lamp monitoring substation. As a transit device, it is an important bridge of street lamp control terminal and street lamp management center. It can be seen according to simulation test of the system by using NS2 software that the average delivery rate of the system is kept in the range of 99.5% with higher reliability and availability. It can be seen from the power consumption analysis of a single street lamp that compared to the traditional high-pressure sodium lamp, the LED street lamp based on the street lamp wireless monitoring system can save 1.18 kW·h per day, and has very remarkable energy saving effect. Although this design introduces the design of the street lamp monitoring subsystem and the street lamp control terminal in detail, there are still some deficiencies in their reliability testing.

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Research on the Innovation of Urban Street Visualization Light Monitoring System based on GIS Technology

作者:Liu, YR (Liu, Yanrong)[1]

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摘要 The current street monitoring is more traditional way, backward management and inefficient. Now on the street lamp monitoring system research is the use of wireless network technology and GIS technology to achieve automatic monitoring of street lamps, but the lack of street lamp system logic structure analysis. According to the physical model of street lighting facilities, the paper analyzes the logic model, and designs the visualized streetlight monitoring system by C / S mode. In the system, the user can quickly find the location of the street controller through the map, and bulk control of a range of lights off, thus breaking the current simple way to control the street, the real realization of the picture to see the lights, Lights, lights to view the service.

关键词

作者关键词:Urban Street Light; Monitoring System; GIS Visualization

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Research on the Innovation of Urban Street Visualization Light Monitoring System based on GIS Technology

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Keywords: Urban Street Light, Monitoring System, GIS Visualization

Abstract. The current street monitoring is more traditional way, backward management and inefficient. Now on the street lamp monitoring system research is the use of wireless network technology and GIS technology to achieve automatic monitoring of street lamps, but the lack of street lamp system logic structure analysis. According to the physical model of street lighting facilities, the paper analyzes the logic model, and designs the visualized streetlight monitoring system by C / S mode. In the system, the user can quickly find the location of the street controller through the map, and bulk control of a range of lights off, thus breaking the current simple way to control the street, the real realization of the picture to see the lights, Lights, lights to view the service.

Introduction

Street lights are an important part of municipal facilities and street lamp monitoring system is a very important indicator of the level of urban modernization. The traditional street lamp monitoring system mainly relies on artificial or timed clock to control the switch, because each section carries out the independent control of the section, and there is an error between the timers, which causes the street light to open and close is not unified, and because of the lack of the corresponding detection means cannot monitor the working state, management backward, inefficient. Therefore, the use of new management methods and technology to achieve street lamp monitoring is the urgent need for street construction and management. At present, the research of street lamp management system mainly introduces wireless network technology and GIS technology to realize the automatic monitoring of street lamps. However, these studies only describe in detail the design method using wireless network and GIS technology, the lack of analysis of the topology of the street lamp, and the logic model of the streetlight system is not clearly given, which seriously affects the operation efficiency of the monitoring system. In order to solve these problems, the author uses the database technology to analyze the physical model of the streetlight system and establishes the relational structure model of the system. On the basis of the relationship between the street and light system, the system database is established and the visualization of the streetlight system is realized by GIS technology monitor.

Present Situation Analysis of Visualization Technology of Street Lamps

In recent years, with the development of the city, the installation of various types of street lighting facilities in the continuous improvement, and, urban lighting has evolved from a simple lighting function to beautify the urban environment, improve the image of the city an important part of investment. The larger the city, the more the amount of street lighting facilities, coupled with various types of supporting facilities, such as control boxes, cables, etc., together to build a large, complex urban street lighting system. With the completion of the construction of the entire street system, the monitoring and management of the various street lighting facilities in the whole system is also a huge project, especially to monitor the system when the street lamp facilities failure, should achieve rapid positioning, repair. How to ensure the city's street lamp system efficient and safe work, to achieve a variety of street lighting facilities visualization, information monitoring and management has become a hot research.

Traditional street lamp management mainly take semi-automatic or manual way, although to a certain extent, to achieve real-time monitoring of street lamps, but fundamentally speaking, still did not achieve visual monitoring, the main information transmission instability and other three aspects:

With the continuous expansion of urban roads, street lamps and other equipment more and more, its function tends to be complicated, showing a massive and discrete data characteristics, which greatly increased the workload of street monitoring. As the monitoring unit lacks the scientific information transmission and the gathering plan, causes the street lamp terminal equipment to obtain the information hysteresis, the perception is not flexible, the data transmission speed is slow, the data wrong package and so on.

The number of street monitoring terminals and the geographical position are superior, showing the cross state, because of this, in the design of street monitoring system, usually ignore the visual display equipment running state of work, making it impossible to real-time monitoring of street lamp operation, Process, there is no control and monitoring functions of organic unity, which cannot directly through the system platform to master the working status of street lamps.

The traditional street lamp monitoring methods are mainly inductive control, photoelectric control, always control to semi-automatic and manual management, focusing on a section of the street lights to monitor, cannot be very good to achieve a single street lamp control, especially in the visual aspects lack of certain accuracy. Currently used in street lamp monitoring technology mainly Zig Bee technology and communication technology, but it is only used in voltage, signal wave stability of short-distance communication, the scope of application is small.

The number of facilities: a city in the size of the road or the district are basically equipped with street lighting facilities for lighting, coupled with the matching control box, cable, the total amount is calculated in million units, The amount of information is huge: each street lighting facilities have a certain amount of attribute information, such as geographical location, power, controlled information, monitoring information, due to the huge amount of its own facilities, so the amount of attribute data is also quite large. Spatial location characteristics: street lighting facilities are basically based on urban road network design and laying, so with the geographical space characteristics, especially in the monitoring system in the early warning information positioning, spatial features more obvious.

It is difficult to realize the spatial location of early warning information: Because the monitoring and early warning information has strong spatial position characteristics, the current monitoring system can only be used in the form of text difficult to achieve spatial analysis function: In order to rationalize the deployment of staff and equipment, usually need to analyze the entire street lamp system in the early warning of the fault (such as the address text description), that failure, cannot do warning failure of the spatial location of visualization and positioning; it is difficult to meet the requirements of information sharing: the establishment of street light monitoring and early warning information platform to achieve the street lights monitoring system of digital information construction, the development of street light monitoring and alarm system is the development trend of the entire industry, and the current street monitoring system of various data and data organization decentralized, management unstructured, difficult to achieve data sharing requirements.

System Function and Its Design Research

The streetlight monitoring subsystem is a visual display of the streetlight status, which monitors the state of the street lamp in real time. The subsystem is the main subsystem of the streetlight monitoring system. The subsystem also provides two functions of status query and data query. State of the query is divided into communication test, current query and mode query three functions. Communication test for testing the upper and lower computer communication, you can understand which the next bit machine can be successfully controlled, which under the machine communication problems cannot be remote control, so that maintenance personnel in a timely manner. The current query can query the current of each detection channel corresponding to each lower computer, and can truly reflect the working conditions of the load by the current value so that the operator can understand the field control situation. The mode query is a query on the mode of operation of the

lower computer so that the operator can understand the working mode of the lower computer and avoid the misoperation of the lower computer when the host computer is restarted. The data query subsystem contains basic information queries and thematic queries. Basic information query refers to the user through the road name, interest name, such as a certain building, you can quickly find the location of the data on the map where the space and can view the surrounding data information. Special information query refers to the user on the electronic map users click on a street or a distribution box, you can view the basic information of the street or distribution box.

Street lighting system equipment is very complicated, according to its operating characteristics can be divided into simple equipment, complex equipment and lines. Simple equipment is with headlights, siege lights and high pole lights, complex equipment, box-type change, landing table box, distribution room and wiring wells. Line lights have power lines, street lights control lines, power lines are divided into the main power lines, power lines, power lines, including sub-supply lines and branch lines.

Street lights in the state will consume a lot of power, energy in the lack of modern society, how to achieve energy-saving emission reduction is a hot research. Therefore, the system considers how to minimize the consumption of energy in the case of sufficient pedestrian demand. Each circuit of the distribution box is not controlled by the geographical position of the continuous distribution of street lamps, but the control of the street lights separated by two lights, a street on both sides of a distribution box by the three circuits control. In addition, the system uses the control system at intervals of two lights, in general, every night from 17:30 to 19:30, street lights separated by two lights, that is, control the road on both sides of the distribution box circuit all the way in the "open" State; from 19:30 to the next day 1:30, at this time more pedestrians on the road, in order to fully meet the needs of pedestrians, all lights are in the "light" state; from 1:30 to 6:00 the next day, Two lights of the control program; daily 6:00 to 17:30, street lights are in the "light off" state.

MapX is MapInfo company to provide users with a powerful map analysis of the ActiveX control products. Because it is a Windows operating system based on the standard controls, which can support the vast majority of standard visual development environment such as C #, Delphi, VisualC + + and so on. Programmers in the development process can choose their own most familiar with the development language, easy to map function embedded in the application, and can be out of Maplnfo's software platform to run. The basic operation of the electronic map includes the zoom display of the map, the mouse to achieve the map of the zoom, zoom, roaming and other basic operations.

As the display scale grows, the map display layer increases accordingly, displaying the map content more and more rich and detailed. Data query, according to the query results, the map according to a certain scale to the query results, and make the query results highlighted highlight. The design of the street monitoring system using C / S mode, the client uses C # as the development language, the use of VisualStudio 2008 platform for the second development of MapX. Realize the real-time monitoring of street lamps, visually display the working status of street lamps and distribution boxes. In addition, the system also provides users with a friendly man-machine interface to help users easily use the system. The server of the system uses SQLServer, according to the relationship between the street lamp system structure model, the establishment of street monitoring system database for the system storage and provide GIS data and street lamps, distribution boxes and other equipment data. In the GIS database side, the database through the spatial data engine SDE through the window of the street color (gray light "light off", green said "light"), you can clearly get the work of the various lights. This interface gives the physical structure of the distribution box model and you can directly through the operation of the distribution box to change the work of the street lights to achieve the visualization of street lights.

Conclusion

The system uses GIS and database technology to complete the street lamp monitoring system design, the system not only uses the relational database to organize data, but also provides a visual street light status detection interface. However, due to time, knowledge and technical reasons, the system

there are some shortcomings. Function: the system module function is not very comprehensive, cannot edit the elements of the layer, the query only supports accurate query, does not support fuzzy query. Technical aspects: The system does not consider the actual use of lights and distribution boxes in the communication problems, in the future work should be introduced wireless transmission module, enhance the practicality of the system.

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Research on Network Packet Analysis Technology Based on Capture and Filtering

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Abstract

In order to solve the shortcomings of the traditional analysis technology, such as low analysis precision and weak generalization ability of the high frequency component of the data packet sequence, a network packet analysis technique (NPAT) based on capture and filtering (BCF) is proposed. The data packet sequence is decomposed by multi band preprocessing through BCF. Then the Optimizing network data package (ONDP) is optimized by NPAT, and the data sequence of the single arm reconstruction is analyzed. The analysis values of each sub sequence are superimposed to obtain the actual analysis results. The experimental results show that the method can master the change rule of the impact burr in each frequency band of the network packet sequence, which has good analysis accuracy and generalization ability.

Key words: Nonlinear; network packet; generalization ability; capture and filter

1. INTRODUCTION

Packet analysis is an important part of network system platform planning, and its analysis accuracy directly affects the system's economy, security and service quality. With the massive multiplication and complexity of network data, autoregressive moving average (ARMA) model of traditional linear statistics, differential autoregressive moving average (ARIMA) model and differential autoregressive summation moving average (FARIMA) model has been unable to guarantee the accuracy of chaotic nonlinear network resources in short-term packet analysis. However, due to the shortcomings of these intelligent technologies, the accuracy of the optimized analytical model still needs to be improved.

The current definition of computer network security is that confidential data information contained in the hardware part, software part and network system of the computer network system cannot be invaded and lost, and the data information is not damaged, tampered or leaked because of accidental or deliberate destruction. The computer network system can be continuously and steadily run, and the system network will not be interrupted.

For computer network security issues, it has been widely concerned at home and abroad. Computer network expands the scope of application of data information security. However, the purpose of ensuring the security of network information data is to better carry out the use of nuclear e-commerce in the packet network. For example, for networking booking on the memory network, because of the need for network payment, it has the problem of network information security. With the rapid development of computer network and data information security industry, the research and development of computer network information security technology has attached great importance to all over the world and the development of firewall technology has been further promoted. At present, there is no password technology in the domestic import information security technology, and the U.S. government is also prohibited from password technology. China also does not allow the introduction of password technology, and even expressly prohibit foreign password products in our country propaganda or display. In the world, some standardized Telecom security protocols and communication standards all contain security standards. However, the standard of cryptographic technology has not yet been specified. Many scholars at home and abroad pay great attention to the research of secure cryptography, and the media also carry out large-scale publicity. Although hackers have begun to report memory related issues, but it has not yet involved in the field of password security. With the rapid development of computer network technology and the advent of the Internet era, the Internet problem has been urgent, but the main concern is Hackers' attacks on the network, and the password level has not yet involved. In today's society, the development of network technology is extremely fast. The whole society's life is closely related to the network, which also appeared a series of network security issues. To solve these problems, the whole network domain gives the corresponding solutions, and the better solutions are hacker attack detection, potential threat scanning and network protocol analysis.

Nowadays, the network has been widely developed in various fields of society, and it has produced a series of operation rules, including two aspects of hardware and software. All of these agreements are collectively referred to as rules. In order to transmit the network data correctly, the data must be packaged into a data packet according to the protocol format, so that the data can be sent and received smoothly. Of course, the type of protocol is diverse. Therefore, the packaged data packets should be corresponded with the corresponding

protocols before sending. And it also conforms to the management and security requirements of the network. Protocol analysis is very important, because now the network data transmission involves some traffic billing problems, which requires high accuracy of traffic statistics, so reasonable protocol analysis is an effective way to solve this problem. In addition, protocol analysis can make people better understand the network situation, so as to better deal with network failure. The protocol analysis is a very effective means to filter the protocol and content of the packaged data packets. According to different transmission protocols, the data packets transmitted in the network are extracted, and then analyzed and restored, so that customers have a better understanding of the network. How to evaluate whether a network analysis system is perfect is a very important issue. The realistic social demand gives the answer, such as the analysis report of some network problems, the query of the flow and the utilization of the bandwidth. Only when these problems are solved can the fault be solved reasonably and efficiently. In order to ensure the security of a network system, a lot of problems need to be solved. The most important thing is the collection of network data, the core of which is to grasp the network data by request, so that these data can be used rationally. Of course, the connection of the network interface and IP address conversion are also very important aspect.

In view of the characteristics of network packet changes and the shortcomings of existing optimization techniques and data preprocessing, this paper proposes a packet data analysis method based on capture and filtering (BCF- ONDP- NPAT). And the network platform is analyzed with 100h in advance. The experimental results show that the BCF packet search algorithm can effectively optimize the network packet and improve the accuracy and generalization ability of the analysis method after the data packets are captured and filtered.

2. BCF-ONDP-NPAT ANALYSIS MODEL

Technical route of BCF- ONDP- NPAT analysis model:

a. The sequence is transformed into complete frequency domain analysis sequences by capturing, filtering (BCF) and multi band pre-processing data packet sequences.

b. Use ONDP to analyze and process decomposed subsequences.

c. Because the analysis involves the evaluation of weights and threshold parameters, the NPAT technique is used to search for the optimized parameters.

d. Because NPAT has the local optimal defect, CSC is introduced to optimize the technology.

e. Processes sub sequences through BCF-ONDP. In the optimization model, ONDP provides mean square deviation (Mean square deviation, MSD) for analysis of BCF, while BCF optimizes training according to mean square deviation MSD, and provides threshold theta and weight Omega for ONDP.

f. Superimposed the sub sequences of each analysis component obtained by BCF-ONDP training to obtain the actual analysis results.

The detailed steps of the input and output of the analytical model are shown in figure 1.

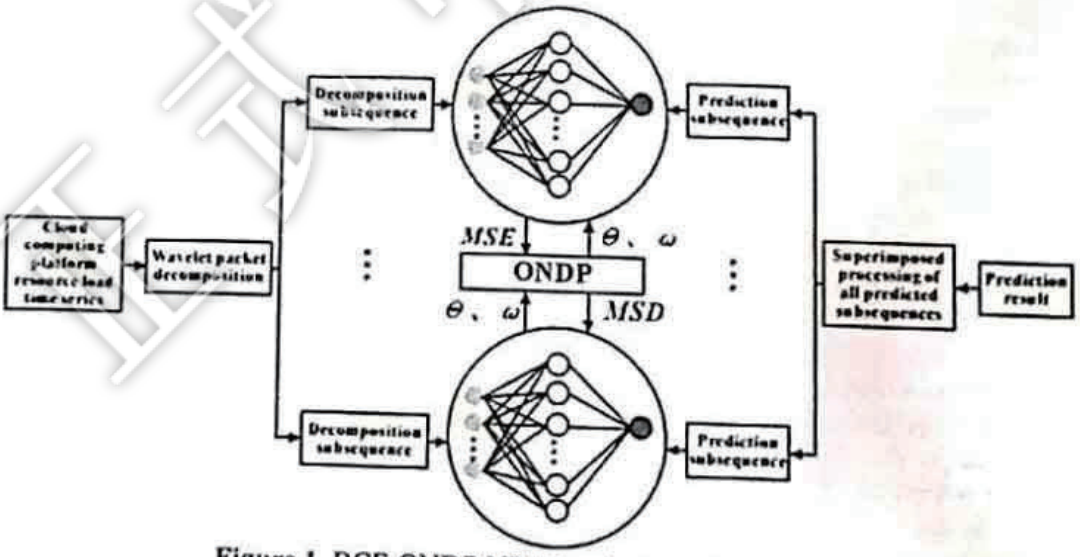

Figure 1. BCF-ONDP-NPAT analysis model diagram

3. NETWORK PACKETS BASED ON CAPTURE AND FILTERING

3.1. Basic capture and filtration

The analysis process of NPAT technology is mainly divided into the following three aspects, in which the switching of the convection function and the encircling contraction link is determined by the random parameter A in the interval [-2, 2].

1) Convection function. When -1≤A≤1, the convection function uses the random single data X_{rand} of the packet to find the optimal data, such as equation (1).

$$X_{t+1} = X_{rand} - A \cdot D \tag{1}$$

Among them, X_{t+1} is the coordinates of the t data after the update of the single data position. $D=|C\cdot X_{rand}-X_t|$ represents the distance between the current single data X and the random single data X_{rand}, and C is a random number range of [0, 2], which controls the distance between the X_{rand} and the X.

2) Surround contraction. When A<-1 or A>1, suppose that capture and filter find the global optimal single data location X_{best}, begin to encircle the data, shrink the search range, such as the formula (2).

$$X_{t+1} = X_{best} - A \cdot |C \cdot X_{best} - X_t| \tag{2}$$

3) Spiral lookup. Capturing and filtering data while searching the optimal single data *Xbest*, it also tracks the motion of a logarithmic spiral trajectory, such as (3).

$$X_{t+1} = D_{best} \cdot e^{bl} \cdot \cos(2\pi l) + X_t \tag{3}$$

Dbest=|*Xbest* −*Xt*| represents the distance between the single data *X* and the optimal single data *Xbest*, B is the constant to model the spiral trajectory, and *l* is the random number on the interval [-1,1].

3.2. Network packet optimization

Capture and filter optimize the network packet with the coordinates of the optimal single data *Xbest* in the process of spiral search. It can not only accelerate the convergence rate at the later stage, but also lead to the rapid aggregation of individual data in solution space, so as to speed up the decline of packet diversity, and increase the probability of technical analysis. In order to reduce the possibility that a single data can be gathered into a local minimum region, the capture and filtering are introduced to control the motion region of a single data packet to improve the ability of the technique to jump out of the local optimum. The calculations are shown in formulas (4) and (5) respectively.

$$X_{t+1} = X_t + r_1 \cdot e^{br_2} \cdot \sin(2\pi r_2) \cdot |r_3 X_{rand} - X_t| \tag{4}$$

$$X_{t+1} = X_t + r_1 \cdot e^{br_2} \cdot \cos(2\pi r_2) \cdot |r_3 X_{rand} - X_t| \tag{5}$$

The function of the parameter r_1 is to control the range of the network packet, and its calculation is shown in formula (6).

$$r_1 = a - a \cdot \frac{t}{T} \tag{6}$$

Parameter r_2 is an optimization operator based on cubic chaotic maps. Compared with the general operator sequence, it has better equilibrium ergodicity and convergence efficiency, and its calculation is shown in formula (7).

$$r_2^{t+1} = \begin{cases} rand[-1,1], t = 0 \\ 4\left(r_2^t\right)^3 - 3r_2^t, t \geq 1 \end{cases} \tag{7}$$

In the BCF technology, the input single data of the input package is input, and the optimal solution is calculated by the objective function fobj, and the optimal solution is output. The key parameters are set as shown in 4~7.

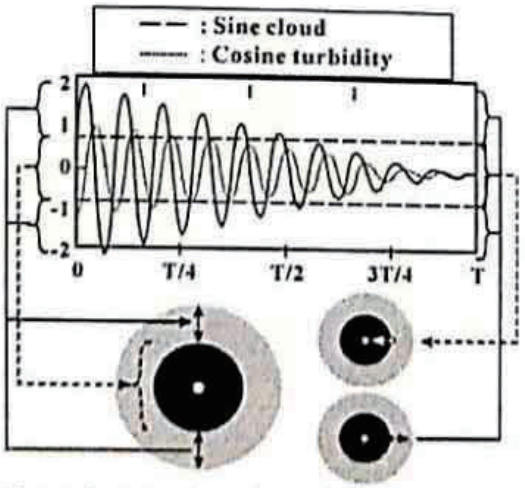

Figure 2. network packet optimization diagram

3.3. *Improve capture and filter*

The three-layer ONDP is the simplest network suitable for arbitrary nonlinear analysis and processing, and its generalization ability and processing efficiency are superior to other data. However, in the process of ONDP analysis, the gradient descent method is used to adjust the threshold and weight of the network, which leads to slow ONDP analysis and is easy to fall into local extremum, which reduces the accuracy of analysis. BCF technology has good convergence speed and the ability to jump out of the local optimal solution, which provides the possibility to overcome the shortcomings of ONDP.

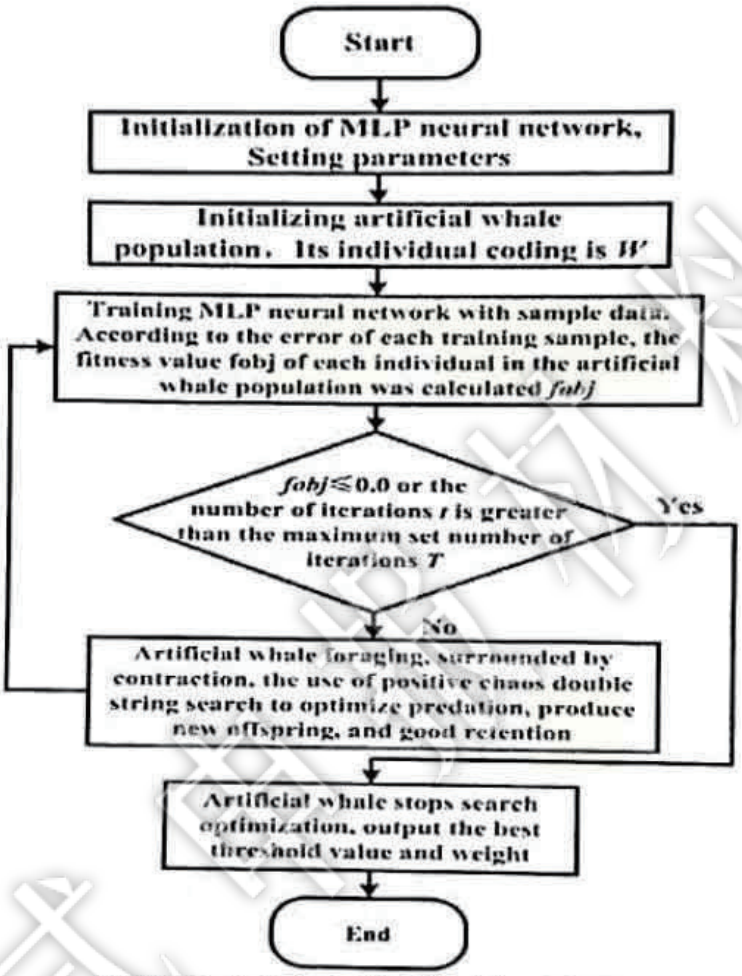

Figure 3. flow chart of BCF training ONDP

BCF-ONDP input the data of the bun sequence, output the packet value of the analysis, and the processing steps are shown in figure 3. Setting of the key parameters: the ONDP neural network with three layers structure is adopted. The number of nodes in the input layer is n. The number of hidden layers is 1. The number of nodes is h, and the threshold and weight are θ and ω respectively, then capturing and filtering single data encoding is $W_{i=1,\ldots,N} = \{\omega_{11}, \omega_{12}, \ldots, \omega_{nn}, \theta_1, \theta_2, \ldots, \theta_h\}$. The calculation of the fitness value fobj for capturing and filtering each single data in a packet is shown in formula (8).

$$fobj = \overline{MSE} = \sum_{k=1}^{S} \frac{\sum_{i=1}^{m} \left(O_i^k - d_i^k\right)^2}{S} \tag{8}$$

In the formula (8), m is the number of nodes in the output layer, o is the actual output value of the ONDP neural network, d is the expected output value, and S is the total number of training samples.

4. PACKET ANALYSIS TECHNOLOGY

The network packet used in this paper is provided by an operator network platform, and the time interval of data statistics is 1 hours, that is, each valid sample collection point is counted by the network traffic data packet within 1 hours of the platform. From the original sequence of Figure 4, there are more burrs on the load curve of the network platform, but the burr caused by the impact load is not bad. If the data preprocessing

cannot be effectively handled, it will affect the accuracy of analysis. The time series of capturing and filtering preprocessing network packets are introduced here.

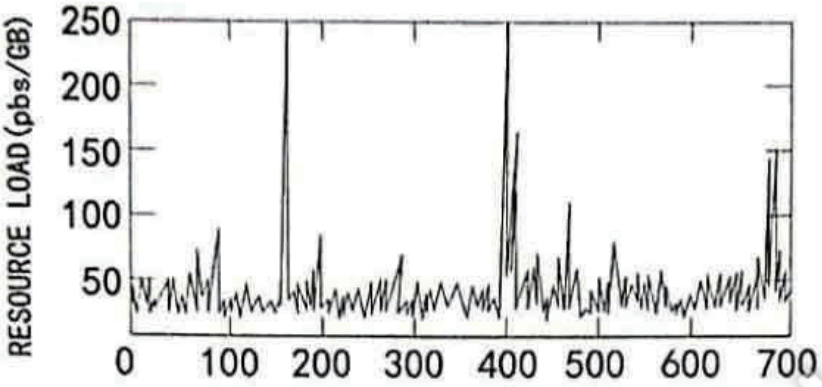

Figure 4. data packet sequence of a carrier network platform in September 2016

Through the input of the original signal sequence, the pass filter is used to decompose, and then it outputs the corresponding frequency domain analysis subsequence. The set of decomposition functions and coefficients is shown in formula (9).

$$\begin{cases} d_l^{i+1,2n} = \sum_k h_{k-2l} d_k^{i,n} \\ d_l^{i+1,2n+1} = \sum_k g_{k-2l} d_k^{i,n} \end{cases} \tag{9}$$

In the equation (9), d is the capture and filter band coefficient, i is the decomposition layer, while h_k and g_k are the coefficients of the capture and filter conjugate filter, K is the time parameter of the position index, and l is the frequency parameter of the scale index.

In the two layer decomposition graph of capture and filter in figure 5, AA2 and AD2 are subsequences of the low frequency part of an analytic signal, and AA_2 is the main component of the AD_2 data packet sequence. AD_2 and signal high frequency partial subsequences DA_2 and DD_2 are random variables in the packet sequence. The method of network packet analysis can increase the analysis of high frequency components, and can search the change rule of the impact burr in the packet sequence more carefully, which is helpful to improve the analysis accuracy and generalization ability of the analysis model.

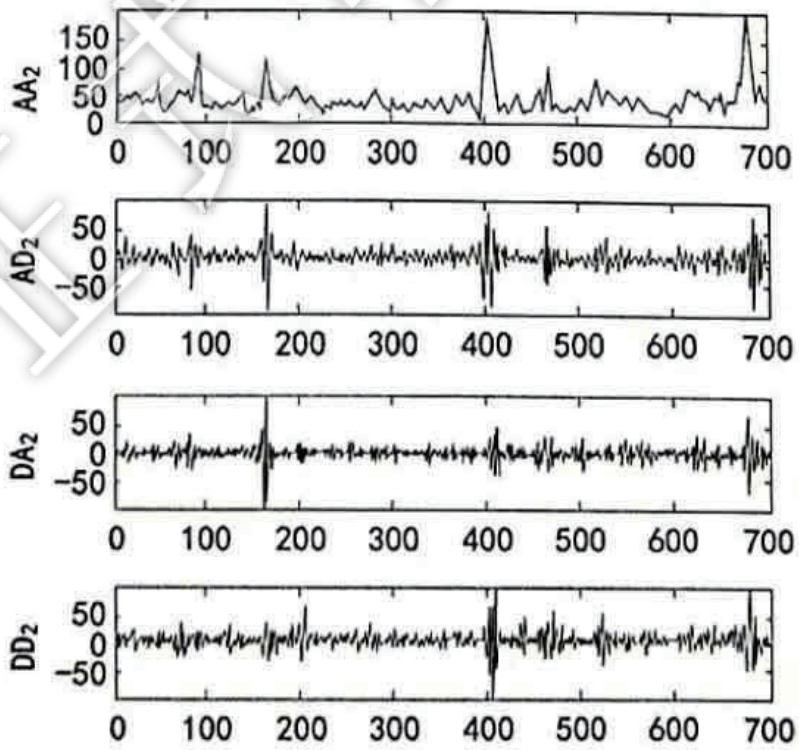

Figure 5. capture and filter sequence diagrams for decomposing data packets

5. EXPERIMENT

In order to verify the accuracy and generalization ability of the proposed method, this paper use the original ONDP model, WD-BCF-ONDP model, Particle Swarm Optimi-zation (PSO), BCF-PSO-ONDP and BCF-GA-SVM optimized by Genetic Algorithm (GA) technology as the reference method and the BCF-ONDP-NPAT method are compared.

5.1. Experimental parameter setting

The decomposition layer number of BCF and WD data preprocessing is 3. The number of hidden layers in each analysis method is 1 for ONDP. The number of nodes in the input layer is 6. The number of nodes in the hidden layer is 10. And the number of nodes in the output layer is 1, so the single step network packet analysis is carried out.

The training data are from the historical data of September 2016 in the third section. From the 700 valid sampling data points, the first 600 samples are taken as the training sample set, the latter 100 as the test sample set, as shown in figure 6. The $c_1 = c_2 = 2$ of PSO, the crossover and mutation rates of GA were 0.9 and 0.02, respectively.

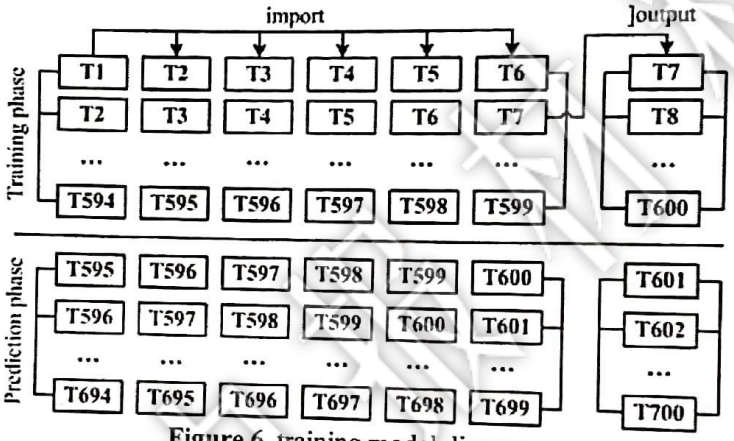

Figure 6. training model diagram

The analysis method of simulation experiment was programmed by Matlab. It runs 30 times independently in the Intel Pentium I3 dual core processor, 4G memory and Window7 system environment. The experimental results are shown in table 1.

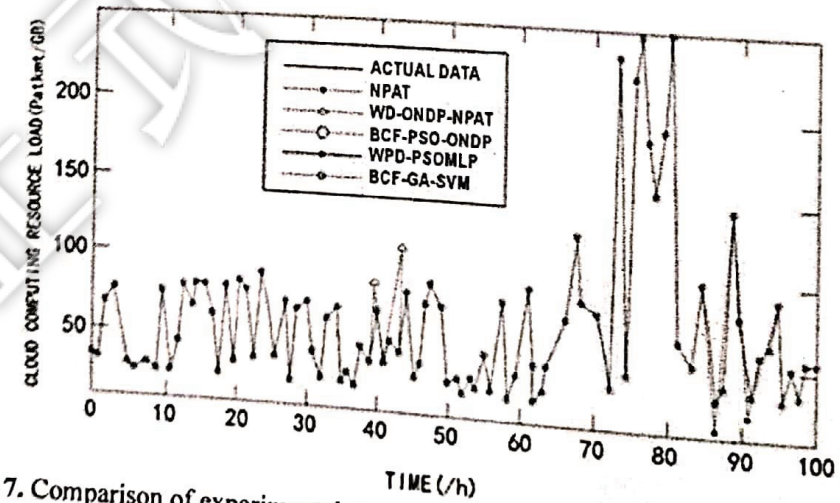

Figure 7. Comparison of experimental results of cloud packet analysis in September 2016

Table 1. comparison of experimental results of cloud packet analysis in September 2016

Analysis method	MAPE	Std(MAPE)	MAE
ONDP	27.16	0.798	3.194
	3		

WD-BCF-ONDP	1.425	0.225	0.212
BCF-BCF-ONDP	1.072	0.057	0.101
BCF-PSO-ONDP	1.152	0.191	0.132
BCF-GA-SVM	1.236	0.232	0.159

5.2. experimental results analysis

From Figure 7 and table 1, it can be seen that the BCF-BCF-ONDP analysis method is more accurate than the other analysis methods in searching the change law of the impact burr of the packet sequence, and the analysis results are closer to the actual value. The analysis results of WD-BCF-ONDP and BCF-BCF-ONDP show that the analysis accuracy of the latter is obviously better, reflecting the advantages of high frequency signal analysis of capture and filtering pretreatment, so the analysis accuracy is higher. Compared with BCF-PSO-ONDP and BCF-GA-SVM, BCF-BCF-ONDP analysis results of MAPE were decreased by 6.94% and 13.27%, which reflects the advantages of BCF technology in the analysis. It can enhance the ability of technology to jump out of local optimum, and adjust the weights and thresholds of ONDP neural network adaptively, so as to improve the accuracy of analysis.

In order to test the generalization ability of BCF-BCF-ONDP, the sampling data of March, June and September 2016 were selected from historical data sets for comparative analysis. The experimental results were shown in Table 2 and figure 8-10.

Table 2. packet analysis of BCF-ONDP-NPAT in March, June and September 2016

Analysis method	MAPE	Std(MAPE)	MAE
March	1.328	0.059	0.138
June	1.584	0.069	0.172
September	**1.072**	**0.057**	**0.101**

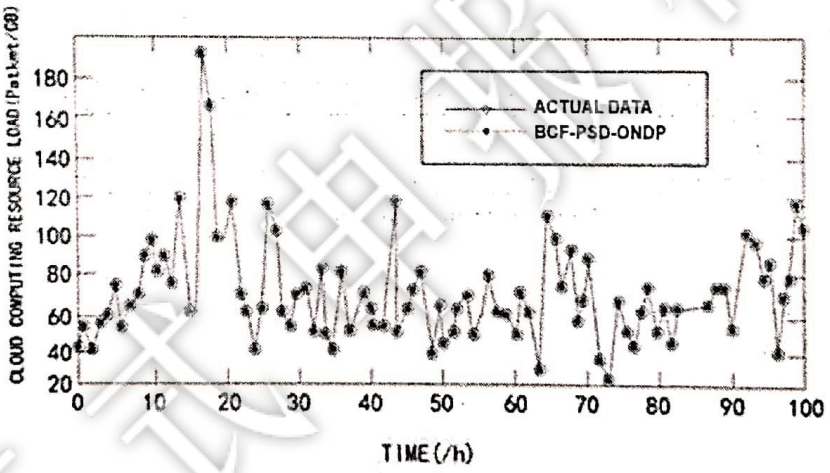

Figure 8. BCF-ONDP-NPAT packet analysis diagram in March 2016

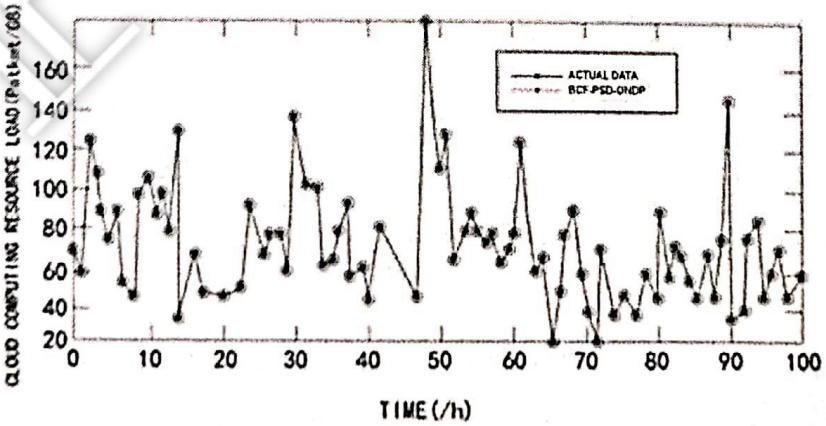

Figure 9. BCF-ONDP-NPAT packet analysis diagram in June 2016

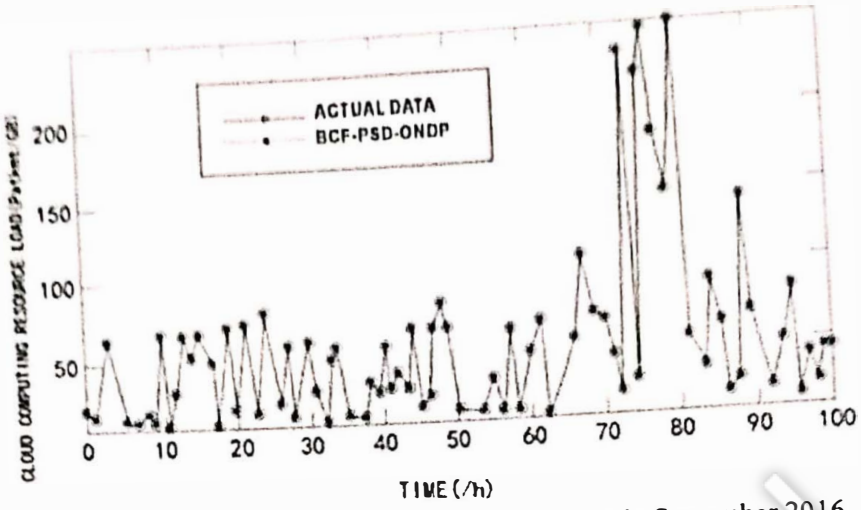

Figure 9. BCF-ONDP-NPAT packet analysis diagram in September 2016

From table 2 and figure 8-10, BCF-BCF-ONDP achieves higher accuracy in network packet analysis in different months. The maximum percentage is 1.584%, and the minimum is 1.072%. The analysis results are relatively stable.

6. CONCLUSION

A network packet analysis method based on capture and filtering is proposed in this paper. This method uses BCF multi-scale preprocessing network data packet sequence. Then, the BCF technique is used to improve the accuracy of ONDP in the preprocessing of frequency domain subsequences. The experimental results show that the method can master the change rule of the impact burr in each frequency band of the network packet sequence, which has good analysis accuracy and generalization ability.

Acknowledgement

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Self-adaptive Sensor Network Routing Algorithm Considering Multi-phase and Multi-field Coupling

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Abstract

Aiming at the problem of energy consumption dissipation in self - adaptive sensor networks, a self - adaptive sensor network model was constructed. a multi - phase multi - field coupling algorithm is introduced based on the analysis of energy equalization routing. The algorithm starts from the overall energy consumption of the adaptive sensor network and takes into account the cooperation between nodes. The multi-phase coupling function of energy and reputation value is defined, and the state transition probability of node forwarding is given. Energy adjustment is carried out according to the income function to solve the equilibrium coefficient between energy and benefit - multi-field equalization, and the node energy balance consumption is realized, extending the life cycle of the network. Simulation is carried out using the probability simulation tool to verify that there are multiple equalization points in the model. It also shows that the model can promote the cooperation between nodes and maximize the life cycle of the self-adaptive sensor network.

Key words: Multi-phase multi-field coupling, multi-field equalization, energy consumption,routing algorithm

1. Introduction

Self-adaptive sensor network consists of a large number of micro-sensors, sensor nodes not only limited energy, the field work environment also led to the replacement of the node and charging difficulties, these factors make the design of wireless sensor networks to consider minimizing node energy consumption The

Self-adaptive sensor network is different from the traditional wireless network, all of its nodes to the convergence node to transmit data, are many-to-one communication network. The distance to the convergence node may lead to the uneven use of energy, so that the local node premature death, causing changes in the network topology. Topological changes lead to changes in routing queries, the nodes transmit power and transmission range should also be made accordingly Adjust, so that the increase in network energy consumption caused by the overall network life shortened, waste of energy is not exhausted nodes, is not conducive to the "green network" construction. Therefore, in the design of wireless network to ensure network quality of service (QoS), to study the problem of uneven energy consumption, to avoid premature death of the node, the effective global energy management, to achieve the "green network" purposes.

Self-adaptive sensor network has the following characteristics: (1) node energy consumption only with the node in which the current state and the action taken, and the node has nothing to do with the historical energy; (2) Only the effective participation of all nodes in the collaboration can help to achieve the maximum network life in the global scope, but the cooperation and forwarding of the nodes will bring about the energy consumption, and thus reduce the life of the node itself, so that the node itself and the global network The existence of life of the game. Therefore, based on these two characteristics of wireless sensor network energy consumption, we use the multi-phase multi-field coupling theory to model the energy dissipation behavior of self-adaptive sensor network nodes, find more equilibrium points, let the remaining energy Nodes involved in doing more work, so as to maximize the purpose of extending the network life.

According to the above ideas, this paper analyzes the research status of energy consumption in self-adaptive sensor networks, establishes multi-phase multi-field coupled energy consumption balanced routing model, and constructs the revenue function of income and energy. The existence of multiple equalization points is proved by the nature of the income function. As a unified framework of energy consumption, data forwarding and node cooperation, the multi-phase multi-field coupling model can effectively reduce the complexity of energy balance problem research.

2. Multi-phase Multi-field Coupling Sensor Network Model Construction

In the self-adaptive sensor network, the energy consumption of the node is only related to the current state and the action taken by the node, which is independent of the energy consumption of the node. Therefore, the behavior has multi-phase multi-field. Therefore, it is possible to introduce the multi-phase multi-field coupling to study the energy balance of wireless sensor networks. It should be noted that node mobility in Ad-hoc networks is an important factor affecting network performance, while nodes of adaptive sensor networks vary

Not so, this article does not consider the mobility of nodes.

In order to solve the problem of energy dissipation using multi-phase multi-field coupling, we need to establish a multi-phase multi-field coupled energy equalization routing model in accordance with the real environment and reduce the complexity of energy analysis. To this end, Coupling model of hypothesis and formal definition.

Assume1: there are N sensor nodes randomly distributed in the area of area $S_{l\times m}$, the transmission radius of each node is r.

Definition1. The multi - phase multi - field coupling model Γ is a five - tuple $\Gamma=(A,U,R,W,P)$, where:

(1)A=$\{a_1,\ldots,a_n\}$ is the set of participating nodes, a_i is the i -th routing node, among为them $1\le i\le N$;

(2)U=$\{0,1\}$ A presents the state of the routing node in each stage, where 1 indicates that the node is willing to cooperate and 0 indicates that the node does not cooperate;

(3) R =$\{ R_{a_1},\ldots, R_{a_n}\}$ is the set of gains for all nodes, R_{a_i} is the revenue of node a_i, where $1\le i\le N$;

(4) $W=\{W_{a_1},\cdots,W_{a_n}\}$ represents the energy set of all nodes, for each node a_i, its energy contains two parameters $W_{costa_i}\in W_{a_i}$ and $W_{remaina_i}\in W_{a_i}$, respectively, that node a_i consumption and residual energy, where $1\le i\le N$;

(5)P node forwarding data probability, $P_{a_ia_j}\in P$ said node a_i to forward the probability of information to node a_i, where$1\le i$, $j\le N$.

Under the initial condition, the node realizes the information of the global node from the acquisition by notifying the neighbor's own information. The cost of the broadcast of the node is the energy consumed by the broadcast. Since the energy consumed by the broadcast is small and only occurs at the time of networking, the residual energy after the broadcast is approximately equal to the initial energy, which is no longer discussed later. In order to discuss the superiority of the multi-phase multi-field coupling model, the determination of each parameter in the model is carried out first. At the same time in order to describe the concise, later we use i that i-th routing node, that is, i instead of a_i.

2.1. Determination of participating nodes

Assume 2. In the multi-phase multi-field coupling model, the experimental area is $l\times l$, the transmission range of each node is $S_C=\pi r^2$, and the node position in the communication range obeys the binomial distribution

Under the above assumptions, the number of nodes in the communication range is $m_c\approx\rho S_C$ _Where ρ is the average density.

Proof. It is assumed that the probability that the source node has k nodes is

$$P(k)=\binom{N-1}{k}\left(\frac{S_C}{S_{l\times l}}\right)^m\left(1-\frac{S_C}{S_{l\times l}}\right)^{N-m-1} \tag{1}$$

when $N\gg 1$, $\rho=N/S_{l\times l}$, $(N-1)/S_{l\times l}\approx\rho$ _Is a constant,similarly $(N-1)S_C/S_{l\times l}$ _Approximation is constant.when $S_C\ll S_{l\times l}$, The binomial distribution (1) approximates the Poisson distribution, that is

$$P(k)\approx\frac{(\rho S_C)^k}{k!}e^{-\rho S_C} \tag{2}$$

$$m_c=\sum_{k=0}^{N-1}k\frac{(\rho S_C)^k}{k!}e^{-\rho S_C}\approx\rho S_C \tag{3}$$

Proof finished.

Assume3. In the multi-phase multi-field coupling model, the vertical component of the node index is not taken into account, and the node coordinates are represented by two-dimensional scalar. The coordinates of node i are(x,y), the coordinates of the source node are(x_0-y_0), and the destination node coordinates is (x_E-y_E).

Theorem 1. The number of nodes that meet the assumptions 1, 2, and 3 is $m_q=\rho\frac{\pi-2}{2}r^2$.

Proof.as showed in Fig.1 The area surrounded by arcs is known by the integral formula $S'=\pi r^2/2-r^2$, $m_q=S'/(\pi r^2)=(\pi r^2/2-r^2)/(\pi r^2)=\frac{\pi-2}{2\pi}\rho(\pi r^2)=\rho\frac{\pi-2}{2}r^2$. over.

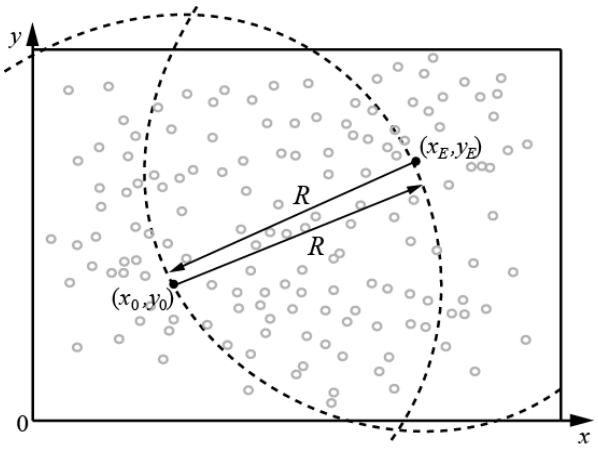

Figure 1. Node communication range

The eligible node should be met:
$(x-x_0)^2+(y-y_0)^2 \le (x_E-x_0)^2+(y_E-y_0)^2$ and $(x-x_E)^2+(y-y_E)^2 \le (x_E-x_0)^2+(y_E-y_0)^2$ A collection of nodes that point to the destination node

$$A_q=\left\{(x,y)\middle|(x-x_0)^2+(y-y_0)^2 \le (x_E-x_0)^2+(y_E-y_0)^2 \text{ and } (x-x_E)^2+(y-y_E)^2 \le (x_E-x_0)^2+(y_E-y_0)^2\right\},$$

Where $m_q=|A_q|$.

Definition 2. The set of participating nodes satisfying the above two assumptions is $m_p=|A_p|$ where $A_p=A_q \cap A_C$.

Under the initial condition, the node set satisfying the node i communication range is A_i . In the self-adaptive sensor network networking stage, the node through the broadcast notice of the neighbors of their own information. In order to carry out the network performance analysis by using the multi-phase multi-field coupling model, it is assumed that the energy consumed by the nodes by broadcasting their own information under the initial conditions is$[W_{cost1},W_{cost2},\ldots,W_{costn}]$,$W_{cost1}\approx W_{cost2}\approx\ldots\approx W_{costn}$. Since the initial energy is equal, the remaining energy of the nodes is almost equal after consuming $[W_{cost1},W_{cost2},\ldots,W_{costn}]$, and the broadcast energy is ignored without affecting the network performance.

2.2. Determination of other parameters

Definition3. Participate in node $a_i \in A_p$ state set U value of 1 or 0. The state matrix is $B_u=[u_1,\cdots,u_m]$, $s_i \in \{0,1\}$.

Under the initial condition, the residual energy of the node is constant and the energy consumption is 0, that is, $W_{remaini}=const$, $W_{cost\,i}$ =0. After the data transfer, the residual energy of node i is

$$W_{remaini}=W_{remaini}-W_{cost\,i} \tag{4}$$

Since the transmission power and the communication distance obey the exponential increase of the parameter γ , $2 \le \gamma \le 4$ when γ = 2, the energy hole problem is inevitable; When γ = 4, it is difficult to achieve the complete energy balance of the whole network area due to the limitation of the maximum transmission distance of the node. Therefore, select γ = 3, so $W_{cost\,i} \propto c_l^3$ and $W_{cost\,i} \propto data_m$, that is

$$W_{cost\,i} \propto k_W \times c_l^3 \times data_m \tag{5}$$

Where. k_W is the energy dissipation factor and $data_m$ is the size of the data. The energy dissipation matrix is $BW_{cost\,i}=\left[W_{cost\,1},\cdots,W_{cost\,m}\right]^T$, the energy residual matrix $BW_{remain}=\left[W_{remain\,1},\cdots,W_{remain\,m}\right]^T$, c_l is the distance from the source node to the destination node

Define 4.the revenue value of node i

$$R_i^{'}=R_i+\Delta R(c_l,data_m) \tag{6}$$

Where $R_i^{'}$ represents the revenue value of node i after the next iteration

Under the initial condition, the income value R_i = 0. ΔR represents the compensation income value, which is the function of the actual communication distance c_l and the size $data_m$ of the transmitted data. Point

to increase the revenue value by forwarding the information .As the cost of forwarding information for the energy consumption, then $R_i = tW_{cost\,i}$, where t is the compensation coefficient. From formula 5 we know:

$$R_i = t \times k_W \times c_l^3 \times data_m \tag{7}$$

let $k_R = t \times k_W$,thus

$$R_i = k_R \times c_l^3 \times data_m \tag{8}$$

Where, k_R is the correction compensation factor. The income matrix is $B_R = [R_1, \cdots, R_m]^T$

Defination5. The number of participating nodes is A_p and the number of elements is *m*. The node forwarding probability matrix is a diagonal matrix, i.e.

$$P = \begin{bmatrix} P_1 & 0 & \cdots & 0 \\ 0 & P_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & P_m \end{bmatrix}, \text{ and } \sum_{i=1}^{m} P_i = 1,$$

Where P_i is the probability that the node i forwards data to the next neighboring node is a function of the source node k's revenue value R_k and the remaining energy $W_{remaini}$ of the node i to be forwarded.

$$P_i = f\left(R_k, W_{remaini}\right) \tag{9}$$

Specifically calculated as

$$P_i = \left(\alpha R_k + \beta W_{remaini}\right) \Big/ \sum_{j=1}^{m} \left(\alpha R_k + \beta W_{remain\,j}\right) \tag{10}$$

Here $W_{remain\,j} > 0$; otherwise $P_i = 0$. Where α is the yield weight, β is the energy weight, and $\alpha+\beta=1$.

3. Multi-phase Multi-Field Coupled Sensor Routing Strategy

In the adaptive sensor network, the energy of the node determines the life of the network. If the number of nodes is too many, the transmission between the nodes will be interrupted and the life of the network will end. At this time, the energy of some nodes is not consumed, resulting in the waste of energy. Multiple multi - field coupling strategy is as much as possible to make the network nodes evenly consumed, to maximize the life of the network.

3.1. Strategic choice

Self-adaptive sensor network node in order to ensure the operation of the network system needs to consume their own energy for data forwarding, but because of their own energy constraints make the node is not willing to forward, so there is a life of their own life and network life between the games. In the multi-phase multi-field coupling model, we need to find this game equilibrium, that is, multi-field equilibrium point. In the multi-phase multi-field coupling model, the income value R_i and the residual energy $W_{remaini}$ are defined, When the node carries forward the data forwarding to increase its income value R_i , according to (10), the next node i to forward the probability of P_i , P_i , that is, the node in the game to take the strategy. This strategy mainly balances the energy consumption of the nodes, thus prolonging the network lifetime, which reflects the balance of the residual energy of the nodes in the form of network lifetime, and the variance $D\left(B_{W_{remain\,i}}\right)$ in the multi-phase multi-field coupling model. When the variance is the smallest, theoretically equals zero, the network lifetime T_{WSN} is the longest. The following is the definition of the self-adaptive sensor network life used in this paper.

Definition6. Self-adaptive sensor network life T_{WSN} refers to the time interval from the network topology to the arbitrary node to collect data cannot be directly or indirectly transmitted to the convergence node and the transmission process cannot be restored. In the multi-phase multi-field coupling model, the network lifetime is related to the variance $D\left(B_{W_{remain\,i}}\right)$, The smaller the variance, the more balanced the remaining energy of each node in the network, and the longer the lifetimeT_{WSN} of the network.

3.2. Calculation of energy

The residual energy of the node is

$$B_{W_{remain}} = \left[W_{remain1}, W_{remain2}, \cdots, W_{remain\,N}\right]^T \tag{11}$$

For any node i, the energy expectation matrix consumed by the first transmission is

$$\begin{aligned} E\left(W_{cost\,i}\right) &= P \times B_{W_{cost}} \\ &= \begin{bmatrix} P_1 & 0 & \cdots & 0 \\ 0 & P_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & P_m \end{bmatrix} \times \left[W_{cost\,1},\cdots,W_{cost\,m}\right]^T \\ &= \left[P_1 \bullet W_{cost\,1},\cdots,P_m \bullet W_{cost\,m}\right]^T \end{aligned} \tag{12}$$

The residual energy expectation matrix is

$$E\left(W_{remain\,i}\right) = \left[cost_1,\cdots,cost_2\right] - \left[P_1 \bullet W_{cost\,1},\cdots,P_m \bullet W_{cost\,m}\right] \tag{13}$$

The residual energy expectation matrix after each transmission is

$$E\left(W_{remain\,i}\right)' = E\left(W_{remain\,i}\right) - E\left(W_{cost\,i}\right)' \tag{14}$$

Where $E\left(W_{remain\,i}\right)'$ is the energy remaining after the data is transmitted, $E\left(W_{remain\,i}\right)$ is the current energy, and $E\left(W_{cost\,i}\right)'$ is the energy consumed by the transmission.

Defines the energy residual matrix of the final node:

$$B_{W_{remain}} = \left[W_{remain1},W_{remain2},\cdots,W_{remain\,N}\right]^T \tag{15}$$

The iterations $B_{W_{remain}}$ are calculated by the following equation (14).

3.3. Calculation of income value

Under the initial condition, the income matrix is

$$R = \left[cost_1,\cdots,cost_2\right]_{1\times N}^T \tag{16}$$

For any node i after the transfer of the income matrix is

$$R_i = \left[cost_1 + \Delta R_1,\cdots,cost_1 + \Delta R_m\right]^T \tag{17}$$

Similarly, the income matrix of all nodes

$$R = \left[cost_1,\cdots,cost_2\right]_{1\times N}^T \tag{18}$$

The existence theorem of multi-field equilibrium in stochastic game: When the number of states and actions is limited, there is a Markov perfect equilibrium in stochastic game.

Theorem 2. In the multi-phase multi-field coupling model with the total number of sensors N, for $\forall P, \exists P^*$ (* denotes a specific element in the set), the T_{WSN} is maximized. That is, there are multiple equalization points, where T_{WSN} is the life of the sensor network, $P^* = f\left(\alpha^*,\beta^*\right)$

Proof.Enegy residual matrix:

$$B_{W_{remain}} = \left[W_{remain1},W_{remain2},\cdots,W_{remain\,N}\right]^T \tag{19}$$

$B_{W_{remain}}$ is the function ofα,β.

For the entire network, if the node mortality rate is $\varepsilon\left(0 \le \varepsilon < 1\right)$, then the node i's successful transmission rate of Λ', then

$$\Lambda' = 1 - \frac{\varepsilon \cdot \left(N/S_{l\times l}\right) \cdot \left(S_C/4\right)}{\left(N/S_{l\times l}\right) \cdot \left(S_C/4\right)} = 1 - \varepsilon \tag{20}$$

If the distance between the source node and the destination node is L, the communication distance is r and the minimum number of communication times is N_{Times}, thus $N_{\text{Times}}=[L/r]+1$, Where [x] represents the largest integer greater than x

In the case of mortality rate ε, the probability of successful transmission from the source node to the destination node

$$\Lambda = \Lambda'^{N_{Times}} = \left(1-\varepsilon\right)^{N_{Times}} \tag{21}$$

Consider the two cases, the node's balanced energy consumption:

(1) no node death situation

At this time the whole network did not appear node death phenomenon, the remaining energy mean and variance were

$$E\left(B_{W_{remain}}\right) = \overline{B_{W_{remain}}} = \frac{1}{N}\sum_i^N W_{remain\,i} \tag{22}$$

$$D\left(B_{W_{remain}}\right)=E\left\{W_{remain\,i}-E\left(B_{W_{remain}}\right)\right\}=E\left\{\left[W_{remain\,i}-E\left(B_{W_{remain}}\right)\right]^2\right\} \quad (23)$$

Standard deviation is

$$\sigma\left(B_{W_{remain}}\right)=\sqrt{D\left(B_{W_{remain}}\right)}.$$

The standard deviation reflects the degree of discretization of a data set, which is the measure of the amount of energy consumed. If the energy consumption is more uniform, the standard deviation is also smaller, the longer the life of the network. When $\sigma\left(B_{W_{remain}}\right)$ = 0, the network lifetime is the longest. Since W_{remain} is a function of α, β, from the above formula, $\sigma\left(B_{W_{remain}}\right)$ is also a function of α, β. From the definition of standard deviation, $\sigma\left(B_{W_{remain}}\right)$ is a concave function. Since α + β = 1, so $\sigma\left(B_{W_{remain}}\right)$ is a one - dimensional function of α, when $\sigma\left(B_{W_{remain}}\right)$ = 0, that is, the minimum value should be satisfied

$$\sigma\left(B_{W_{remain}}\right)'=\frac{d\left(\sigma\left(B_{W_{remain}}\right)\right)}{d\alpha}=0 \quad (24)$$

The solution α * of this equation satisfies the value of $\sigma\left(B_{W_{remain}}\right)=0$, that is, the solution satisfying the game model. According to α + β = 1, find $\left(\alpha^*,\beta^*\right)$ is a multi-field equilibrium point.

(2) node mortality rate is ε

From the formula (20) know, at this time the success rate of node transmission Λ. If you need to ensure the smooth transmission of network success rate Λ 90%, that is, Λ = 90%. At this point, the residual energy with the forwarding function node is

$$B'_{W_{remain}}=\left[W_{remain1},W_{remain2},\cdots,W_{remain\,N}\right]^T \quad (25)$$

Where m has the number of remaining nodes $\left\|B_{W_{remain}}\right\|=\left\|\left[W_1,W_2,\cdots,W_N\right]\right\|$ × 90% of the forwarding function in this case:

$$E\left(B_{W_{remain}}\right)=\overline{B_{W_{remain}}}=\frac{1}{N}\sum_{i}^{M}W_{remain\,i} \quad (26)$$

$$D\left(B_{W_{remain}}\right)=E\left\{W_{remain\,i}-E\left(B_{W_{remain}}\right)\right\}=E\left\{\left[W_{remain\,i}-E\left(B_{W_{remain}}\right)\right]^2\right\} \quad (27)$$

Among them $0\le i\le M$.

Standard deviation is $\sigma\left(B_{W_{remain}}\right)=\sqrt{D\left(B_{W_{remain}}\right)}$, and $\sigma\left(B_{W_{remain}}\right)\ge 0$.

Similarly, the multi - field equilibrium point $\left(\alpha^*,\beta^*\right)$ is obtained when $\sigma\left(B_{W_{remain}}\right)=0$.

In the multi-phase multi-field coupling model, the main research satisfies the above two cases, the network lifetime reaches the longest process, the node forwarding probability Pi is determined, and A $P_i=f\left(\alpha,\beta\right)$, Finally, the multi-phase multi-field coupling model has a multi-field equilibrium point of $\left(\alpha^*,\beta^*\right)$, and each node forwarding information is adjusted according to Eq. (10) to maximize the network equilibrium energy consumption and extend the network life cycle T_{WSN}.

4. Experimental Simulation and Correlation Comparison

4.1. Experimental scenario

The experimental scenario is shown in Table 1.

Table 1. Simulation scene files

parameter	Setting
Node coordinate range	100m×100m
Communication radius	20m
Data length	100bit
Node energy consumption	50nJ/bit ṁ^3
Node initial energy	1000J
Node initial revenue value	50

Income compensation	0.0005/bytes

In the simulation, two nodes are randomly selected as the source node and the destination node, and the source node and the destination node are randomly acquired at the end of the data transmission.

4.2. Node distribution

Multi-phase multi-field coupling model, because the cooperation of the node will consume its own energy consumption, is not conducive to their own survival, so the node cooperation and energy there is a contradiction. The model uses the revenue value of the node to represent the degree of popularity of the node. If the high value of the income indicates that the node has a lot of energy to forward, the node will give priority to the node when it needs to forward the information. According to the above evidence, there is a balance between the energy and the income value of the node - multi-field equilibrium point. The simulation results are shown in Fig.2.

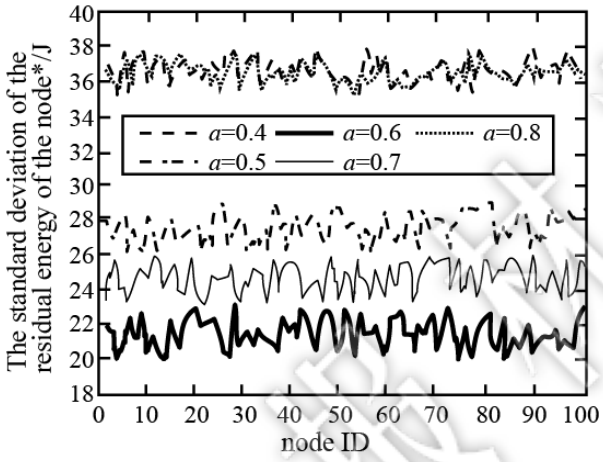

Figure 2. shows the trend of the residual energy of the node with α

When (*α*,*β*)=(0.6,0.4, the variance smallest, the variation range of variance is also the smallest in the simulation process. The weights (α, β) = (0.6,0.4) are the multi-field equilibrium points of the model, i.e. (α *, β *) = (0.6,0.4)

4.3. The residual energy of the node and its variance

The residual energy and its variance of the nodes are shown in Fig. 3. The residual energy curves of nodes under GTEBR and multi-phase multi-field coupling are given. It can be seen from the graph that the energy residual fluctuation of nodes in the multi-phase multi-field coupling algorithm is smaller than that of GTEBR, which is more favorable for the balanced consumption of node energy, which can effectively prolong the network life cycle. Through a number of experiments and (20), we give a comparison of the residual energy variance in the two cases, as shown in Fig.3.

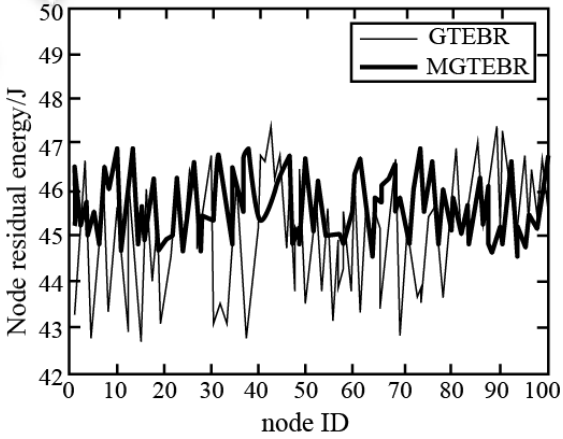

Figure 3. Comparison of remaining energy in nodes

4.4. Average hops

Figure 4 shows the variation of the average number of hops of the algorithm with the number of

simulations. It can be seen from Fig.4 that the multi-phase multi-field coupling algorithm is superior to the GTEBR model in the average hop count, and the EAMHR routing algorithm is optimal. This is because EAMHR is the shortest path route, without considering the node's energy balance problem, but requires the shortest path in the case of data transmission. Although the EAMHR algorithm improves the speed of node data transmission, it is not conducive to extending the network life cycle. Multi-phase multi-field coupling model and GTEBR algorithm fully consider the life cycle of the network, the network life cycle is an important feature of the real network, both models extend the network lifecycle to the maximum extent, and the game algorithm is less than the average number of hops of the GTEBR algorithm. Therefore, the network life of the multi-phase multi-field coupling algorithm in terms of network life cycle and data transmission delay Cycle is better than GTEBR algorithm.

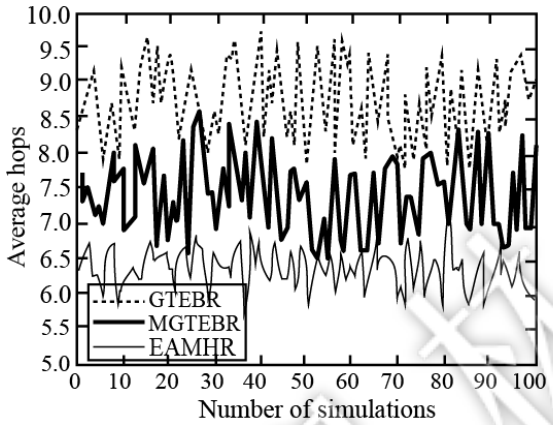

Figure 4. Comparison of average hops

5. Conclusions

Based on the energy balance routing, this paper introduces the multi-phase multi-field coupling into the energy consumption of self-adaptive sensor networks, and establishes the energy consumption of multi-phase multi-field coupling. Based on the multi - phase multi - field coupling, a multi - phase multi - field coupled adaptive sensor network routing algorithm is proposed. The algorithm is used to study the energy balance by introducing the probability model, and the multi - phase coupling function of energy and profit value is defined in the payment function. The multi-field equilibrium of the model is calculated by the income function, and the equilibrium coefficient between the energy and the income value is found out. Experiments show that the proposed model can balance the network energy and strengthen the cooperation between nodes, can extend the life cycle of the network, realize the low-carbon energy saving of the adaptive sensor network, and promote the popularization of the green network.

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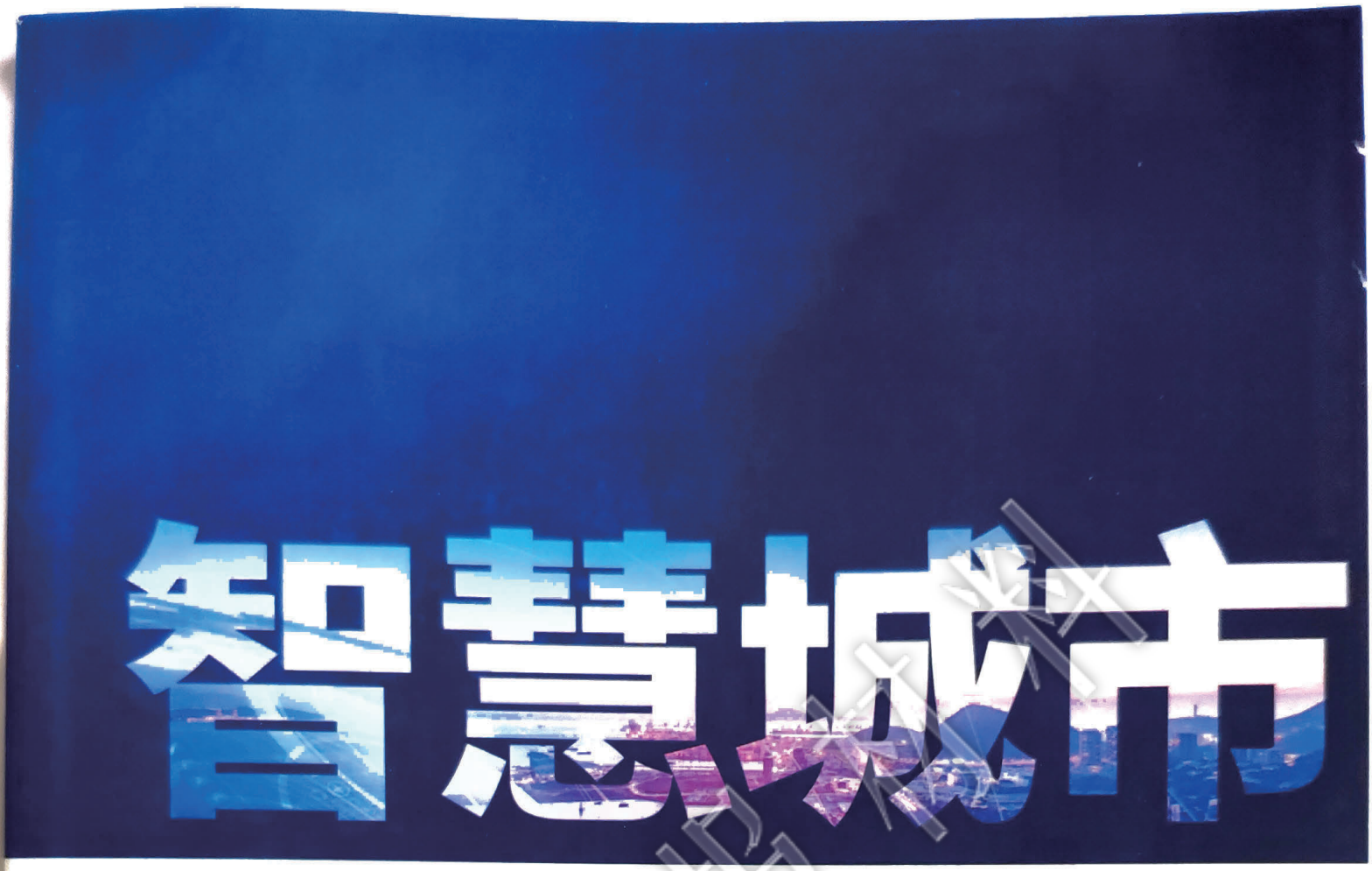

智慧城市

监控系统研究

刘彦戎◎著

西北工业大学出版社

【内容简介】 本书共5章，分别介绍了基于智慧城市中的智能控制系统的创新应用、智慧城市建设中的主要相关技术、智能控制系统、智能控制系统新的发展方向、基于GIS的智能路灯管控系统—以咸阳市路灯控制系统为例等内容。

本书从理论到实践、从规划到运营，逐层分析、详细解读，紧扣时代脉搏，把握城市智能建设和发展的趋势及热点，为相关城乡规划设计单位及人员提供了参考。

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前 言

中国在改革开放经历的几十年中取得的成就令人瞩目，GDP总值超过日本，已跃居世界第二，成为世界的生产、制造大国，为世界经济的增长做出了重要的贡献。特别是当其它一些不发达国家经济发展停滞不前，中国以往的紧急增长模式，今后能否做到可持续的增长，这是世人普遍关心的问题。

当前迅猛发展的信息技术与自动化控制技术相结合的智能控制技术的广泛应用是实现真正意义上的生产、制造大国和实现经济增长模式快速转变的技术支撑和创新基础。这也为智能控制的应用提供了广阔的天地。智能控制在社会生活和国民经济各个生产制造部门的广泛推广应用，将大幅度提高各行各业的劳动生产率，节约能源，改善劳动条件，减轻劳动强度，提高产量、稳定质量和降低生产成本。

《智慧城市监控系统研究》一书，为广大读者系统、全面地阐述了智慧城市建设的基本基础、传感器的技术和各种传感器的一些基本原理；RFID的相关技术原理；无线传感网络技术的基本原理及应用；智能控制系统的概念及咸阳市路灯管控系统的详细设计。

希望广大读者能够通过对《智慧城市监控系统研究》一书的参考，激发出更大的创新和实践能力，为在中国各行各业早日实现中国经济增长模式的转变，提高生产力水平，使中国从目前粗放型的生产、制造大国，尽快转变为创新型强国而贡献出每人的一点力量。

编 者

目　录

▶第1章

基于智慧城市中的智能控制系统的创新应用

改革开放以来，中国城市化发展的步伐不断加快，每年有1 500万人口进入城市。到2025年，中国将会有近2/3的人口居住在城市，中国将进入到一个城市社会。《金融时报》2013年9月21日报道：1980年中国城市人口比例仅20%，而到2016年这一比例将达到45%，中国将是世界上城市人口最多的国家。虽然城市化带来了人民生活水平的提高，但城市要保持可持续发展却越来越受到各种因素的制约，需要转变增长方式、调整产业结构、改变生活方式和不断解决突发性事件等问题。

首先，城市经济保持持续快速发展急需转变增长方式，突破增长极限。城市发展日益受到土地、空间、能源和清洁水等资源短缺的约束，城市人口膨胀、环境保护等问题面临的压力也越来越大。同时，全球城市化进程所带来的严重问题——环境污染成为危害人类健康以及生命安全的主要因素之一。

根据“联合国2019年世界水资源开发报告”，严重缺少影响了大约40亿人，这个数字占世界人口的近2/3。这些问题往往会使原本充满生机的城市逐渐丧失活力。而城市发展面临的深层次问题还包括如何推进节能减排；如何推动城市的产业结构调整；如何建立有效的安全监控网络；如何保证食品、药品的安全；如何有效地整合公共服务设施，最大限度地满足人们在医疗、教育和卫生等方面的需要；如何快速有效地应对突发事件等。这些问题使用传统的技术和管理方法已经难以有效解决，而目前发达国家正在研究如何创新性地使用新一代信息技术、知识和智能技术手段来重新审视城市的本质、城市发展目标的定位、城市功能的培育、城市结构的调整和城市形象与特色等一系列现代城市发展中的关键问题，特别是通过智慧传感和城市智能决策平台解决节能、环保和水资源短缺等问题。

“智慧城市”正是基于这个背景提出，其必要性和紧迫性十分明显。

城市化进程的加快将城市的作用推到了前所未有的高度，当代城市已经成为世界舞台的中心，代表着一个国家或地区的经济和科技的发展水平，成为国家综合国力的象征。与此同时，城市化进程的加快带来的问题也是不容忽视的，城市面临着环境污染、交通堵塞、能源紧缺、住房不足、失业、疾病等多方面的挑战。在新形式下，如何解决城市发展所面临的诸多问题，实现可持续发展，成为城市发展的重要课题。在这种背景下，“智慧城市”成为解决以上问题的一条可行道路，也是未来城市发展的方向。智慧城市的建设将能带动地方经济的快速发展，也将带动智慧交通、智能电网、智慧农业、智慧物流等产业的发展，为相关行业带来新的发展契机。

智慧城市随着通信技术、物联网技术和大数据技术等的发展，越来越得到人们的重视，逐渐成为当代城市发展的新特点。智慧城市为人们提供了合理健康的经济发展模式、便捷的生活方式、绿色的生活环境，极大地方便了人们的生活，对当代社会的和谐发展也起着极大的促进作用，因此得到了世界各国政府的认可。本章将从智慧城市的概念、内涵、组成要素以及智慧城市对当代社会发展所具有的重要现实意义出发对智慧城市进行概述，使读者对智慧城市有大致的了解。

1.1 智慧城市的基本概念

1.1.1 智慧城市建设的基础

随着智慧城市建设的升温，智慧城市建设由概念探索期进入了智慧城市建设实践期，截至2018年11月底，全国已有超过500个城市开展了智慧城市建设，无独有偶，这些城市均提出要加快光纤网络、无线网络建设，把云计算中心、智能电网和智慧管线等智慧基础设施建设作为智慧城市的重点建设项目。而中国城镇化的现状、国家政策和市场趋势导向也都表明，在以后的一段时间内，智慧基础设施是中国智慧城市建设的重点。

中国城镇化现状决定智慧基础设施是智慧城市建设的重点。与发达国家相比，中国的城市发展时间短，存在着宽带网络、通信基站布局不均、城市整体网速较低和测速标准不统一；城市基础硬件（包托城市公共设施、地下管线、电力布线等）老化、智能水平差、融合度低和安全系数差；城市基础软件（平台、支撑硬件的软件）落后、升级难度高、对硬件支撑能力差和信息泄露严重等问题，但智慧基础设施是智慧城市建设的根基，是城市

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发　明　人：刘彦戎

专　利　号：ZL 2015 2 0655287.1

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实用新型名称：一种基于Zigbee技术的无线路灯管控系统

发　明　人：刘彦戎;李景景

专　利　号：ZL 2016 2 0278752.9

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著 作 权 人：陕西国际商贸学院

开发完成日期：2017年09月28日

首次发表日期：未发表

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著 作 权 人：陕西国际商贸学院

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登 记 号：2017SR676230

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No. 02136802

2017年12月08日

证　明

该研究经过对我市路灯状态的调研，获知了咸阳市近70000万盏路灯的分布状态，通过对我市路灯照明监控系统说明书的仔细阅读和对系统的运行情况的实地分析考查，获知该系统采用时控的控制方案，主站自动遥控全市的全夜灯、半夜灯和景观灯的开关和关灯。操作前台机的软件界面，可以设置和修改开关灯的光控照度值。系统可以根据不同类型的灯光控制要求，把全部灯光设备分成若干个组，进行实现群控和组控，在特殊情况下可以按照运行软件的提示，运用前台机的软件按钮，手动对全夜灯和景观灯进行遥控开/关操作。且我市路灯近几年在维护方面一直采用的是配电箱分散管理,人工巡视的方式,管理和维护的效率低、成本较高。

新系统是以日常路灯管控系统平台为依托，以高效、强大的空间数据库和知识数据库为支持，借助于GIS和ZigBee、无线物联网等技术手段，实现了基于网络化、可视化、智能化的实时开放式环境，集信息采集、反馈、控制、自定切换（时控与光控）、联动调度等功能于一体，形成可靠、便捷、自动调控的路灯节能管控系统平台。新系统投入使用一年半以来主要改善了以下问题：

（1）以往我市路灯监控系统信号输出延缓问题(原系统在信号同时输出情况下，第一条街和最后一条街亮灯时间相差将近20分钟）和特殊天气时控和光控的自动切换问题(原系统在特殊天气下不能实现智能化切换到光控模式中)。

（2）提高亮灯率：系统投入运行后可以随时发现路灯运行中出现的问题，随时处理，提高亮灯率。

（3）延长灯具寿命：采用路灯智能控制的情况下。据测试，正常电压（220V）情况下，钠灯电压为100V，电压升高后(230V-240V)，钠灯电压可升至120V-150V；正常电压环境下降压节能运行后，钠灯电压一般为85V，电压升高环境下，钠灯电压可保持在100V左右。从理论和实际使用环境，采用调压控制节能可以延长路灯使用寿命。

（4）节约人力、物力，提高了管理水平：可实时监控每盏路灯、每个路段及亮化工程点工作状态，计算机可以及时对故障进行汇总，写入数据库，以便次日进行维修；利用动态实时模拟显示屏，监视全区路灯，值班员在中央控制室就可以概览路灯现场运行情况，从而减少了巡灯的维护成本和减轻了巡检人员工作强

度，大大提高工作效率。另外，在恶劣天气时，根据各路灯控制智能终端采集的数据情况加以分析，采取相应紧急措施，避免了交通事故的发生。

（5）直接经济方面：投入使用新系统后，可在深夜行人稀少和交通量减少的情况下，执行“隔二亮一”的照明方式，既给夜间出行的行人带来了便利又节约了大量的电费支出。在实现单控方面，达到节能25%。

咸阳市路灯管理处

2018年11月2日

六、附件材料

要求：

1.各成果类型

A．基础研究、应用基础研究：（1）主要论文、著作（限15篇，仅附首页）；（2）被他人引用情况检索证明；（3）科学评价证明。

B．技术开发、发明、推广：（1）技术评价证明；（2）应用证明；（3）相关技术资料。

C．软科学：（1）技术评价证明；（2）应用证明；（3）相关技术资料。

注：科学评价证明包括：他人在学术刊物或公开场合发表的对本成果重要科学发现点（观点、结论）的学术性评价意见，或者验收、评审、鉴定等第三方评价结论。

技术评价证明包括：评审、检测、验收、鉴定、专利证书等。

相关技术资料包括：研究报告、技术总结报告、调查、咨询报告、查新报告、发表著作、论文等。

2.涉及各级政府资助完成的项目，需提交计划项目下达部门同意结题、验收的证明。

3.附件最多不得超过60页。