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Sensor node : sensing, data processing, and communicating capacity.

Sensor network : a large number of sensor nodes that densely deployed (...)

WSN : consists of (spatially distributed) (autonomous) sensors (组成) to monitor physical (or environmental) conditions(目的) and to (cooperatively) pass their data (through the network) (通过什么方式) to sink node.

由于传感器位置不是提前确定好的

Sensor node position not predecided

因此协议或者算法必须是自组织的

Protocols or algorithms must be self-organizing.

WSN的困难

面对物理环境又无人监管

Tight coupling to the physical world and embedded in unattended "control system"

供电少

Energy constraints

耗电多

Communications is primary consumer of energy

WSN 系统设计的两个目标:

long-lived systems that can be unattended

特征有low duty cycle, exploit redundancy, tiered architecture

self-configuring

好处是measure and adapt to unpredictable environment

exploit spatial diversity and density of sensor/actuator nodes (不会预先布置好)

怎么做到呢?

1. Leverage data processing inside the network (通信之前先处理, 减少通信量)
2. Achieve desired global behaviors with adaptive localized algorithms. (采用自组织的算法)

为什么不能直接采用因特网协议和端到端的架构?

WSN can't tolerate communication overhead (of indirection) (WSN不能承担无方向的通信费用)

设计指标:

通信结构需要考虑的目标 (通信结构是WSN系统的一部分, 需要特别关注, 因为是主要耗能)

1. Transmission media (用无线还是有线, 即传播的媒介是什么)
2. Production costs (每个节点的成本)
3. Power consumption (耗能)
4. Fault tolerance (容错)
5. Network topology (拓扑结构, 其实跟耗能有关系, 跟采取信息也有关系)
6. hardware constraints
7. Environment
8. Scalability (要能够增加节点, 增加密度而不会冲突)

什么是WSN的Fault Tolerance?

the ability to sustain sensor network functionalities without any interruption (due to node failures).

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什么是WSN的scalability?

the number of sensor nodes can be increased and new schemes must be able to utilize the high density.

硬件Hardware的4个组成部分: sensing unit, processing unit, transceiver unit, power unit

额外的组成: location find system, power generator, mobilizer

topology maintenance and change in 3 phases
predeployment, post-deployment, redeployment

传输媒介:

often wireless medium,包括radio, infrared, optical

WSN的协议栈有五层

ATNDP

All To Need Dr.Peeper

去掉了people seem

从另一个角度看WSN网络的结构，又可以分成三个管理面

The Power Management (能源管理)

The mobility Management (能动)

The task management (能完成任务)

WSN系统的重要问题

Routing protocols

topology control

coverage problems

time synchronization

localization

Routing protocols:

网络结构划分种类: (节点之间的关系)

Flat, Hierarchical, Location-based.

根据protocol operation划分:

multipath-based, query-based, negotiation-based, QoS-based.

助记: query和negotiation 有点像哈, 先询问再协商; multipath和qos有点像, 多路径来保持质量

根据场景不同, 自行设计协议, 它是能量和通信费用节省之间的权衡, trade-offs between energy and communication overhead savings

挑战:

1. 寻址方面: 不可能给每个节点一个全球性的唯一ID,
it is not possible to build a global addressing scheme

2. 需要从多方面传到一个固定的基站

WSN require sensed data from multiple sources to a particular BS

3. 每个节点有能量 处理能力 和存储的限制

constrained in terms of energy, processing and storage capacities.

4. 有些节点会移动

Most nodes in WSNs are stationary except for a few mobile nodes.

5. 需要定位

Position awareness of sensor nodes is important

6. 数据冗余

Data redundancy

具体需要解决的问题：（有一大部分对应的好处，另一部分对应的是设计挑战）

1. 延长系统的生命周期，防止断联， carry out communication while trying to prolong the lifetime of the network and prevent disconnectivity
2. 节点部署， node deployment
3. 节省能量，并且不损失精度， energy consumption without losing accuracy
4. 数据上报方式： Time-driven, Event-driven, Query-driven, Hybrid
- ...

什么是Flat routing?

Each node plays the same role. Data-centric routing

好处是save energy (through data negotiation) and elimination of redundant data

所使用的协议常见的有： SPIN, DD

SPIN的特征： Negotiation(N), Resource adaptation

工作过程：节点向周围广播发送ADV(advertisement)，受到REQ（请求数据）之后，节点就会向别的节点发送DATA

好处： Simplicity, Robust

坏处： Large overhead（每一跳都需要广播）

DD的特征： Data-centric routing, A path is established between sink node and source node, Localized interactions(只跟周围节点互动)

好处： Small delay, robust

坏处： Imbalance of node lifetime, Time synchronization technique not easy to realize, The overhead involved in recording information

什么是Hierarchical Routing?

Nodes plays different roles.

好处是什么？

scalability and efficient communication

两层路由

select cluster heads and routing.

所使用的协议常见的有： LEACH和TTDD

什么是LEACH?

randomly select nodes as cluster-heads.

需要经过两个阶段， set-up phase 和 steady phase.

经过一段时间后，因为cluster-heads（领导节点耗电快），再进入set-up phase，重新随机选举领导节点

TTDD

什么是Location-Based Routing Protocols?

Nodes' positions are exploited to route data.（即利用位置信息）

什么是Multipath Routing protocols?

Use multiple paths in order to enhance network performance.

什么是Query-Based Routing

Destination nodes propagate a query for data (端节点发送请求，请求数据)

什么是Negotiation-Based Routing Protocols?

Use (high-level) data descriptors in order to eliminate redundant (data) transmissions through negotiation. (通过协商减少冗余信息的传输)

什么是QoS-Based Routing?

Balance between energy consumption and data quality.

什么是Topology control?

改变底层网络从而减少分布式算法的消耗

Topology control is a technique (used in distributed computing) to alter underlying networks (基础网络) to reduce the cost of distributed algorithms.(if ran over the new resulting graphs)

它的目的是什么:

Save energy, reduce interference and extend lifetime of the network.

通过什么方式改变:

via per-node (transmission) power adjustment

有什么好处:

extending network life and increasing network capacity.

Topology control 被划分为哪两个子问题:

topology construction (in charge of the initial reduction) 和 topology maintenance (in charge of the maintenance of the reduced topology so connectivity and coverage are preserved 进一步保证消耗电量后还能维持联通和覆盖)

数学上它是什么问题

Find an MCDS

什么是Coverage Problem?

centered around the question "how well the target is monitored or tracked by sensors(which together constitutes a sensor network?)"

measure of QoS provided by network (衡量质量的方法)

Goal: each location (in the targeted physical space) should be within sensing range of at least one sensor.

area coverage : cover an area

point coverage: cover a set of points

barrier coverage : minimize the probability of undetected penetration through the barrier

Desired Properties of deployment (节点部署的目标)

connectivity and coverage

Time synchronization

为什么需要时间同步？时间同步可以知道什么信息？

1. The time of the day at which an event happened
2. The time interval between two events
3. The relative ordering of events

两种同步方式：

Master-slave & peer-to-peer

The slave node take the master node as reference time.

Any node communicate with every node (in the network) and estimates the local based on (the clocks of) other nodes.

Internal synchronization & external synchronization

内部同步就是让节点之间的最大时间差最小，The goal is to minimize the maximum difference between (the readings of) local clocks (of the sensors) .

外部同步就是让节点和外部时钟的时间差最小，A standard external source of time is provided.

Probabilistic & deterministic synchronization

Provide a probabilistic (guarantee) on the maximum clock offset (with a failure) . (设定一个最大误差，达不到这个最大误差的概率)

Guarantee an upper bound on the clock offset (with certainty) .

Send-to-receiver & receiver-to-receiver
?

时钟同步的困难：

1. 有可能断联，No periodic message exchange is guaranteed.
2. 有延迟，Transmission delay between two nodes is hard to estimate
3. 能量不够，Energy is very limited
4. 节点小，没有设计时钟电路

基本方法：

Collaboration

两种方式去Collaboration

Sender-receiver, receiver-receiver

误差产生：

send time

access time

transmission time

propagation time

reception time

receive time

时钟同步协议：

A self-configuring hierarchical structure.

什么是Localization

To determine the physical coordinates of a group of sensor nodes in a WSN.

为什么不能用GPS

Due to application context and massive scale.

为什么需要Localization

1. To report data that is geographically meaningful
2. Services such as routing rely on location information

Localization 方法的分类

1. Centralized & Distributed 谁决定localize
2. Anchor-free & Anchor-based 有无参考节点
3. Range-free & Range-based 是否计算距离
4. Mobile & stationary

Centralized : All computation is done in a central server

Distributed : Computation is distributed among the nodes.

Anchor nodes: Nodes know their coordinates(by GPS or manual placement)

2D的话需要3个anchor nodes

3D的话需要4个anchor nodes

Anchor-free

Relative coordinates

Anchor-based

Use anchor nodes to calculate global coordinates

Range-free

Hop-Counting (只计算跳数)