Mobile

Exam Questions

- Mobile User Interfaces
- Mobile Games
- Sensors and Hardwares
- Location Privacy
- RFID
- Wireless sensor networks and mobile networks

Overview

Applications

- Digital purchases
- Mobile shopping
- Mobile advertising
- Information Management

    - access to information everywhere (stock, weather, news,...)
- Location-based services
    - connext-aware applications
- Mobile data management

Futures

- Mobile banking
    - already on the go
    - Payments (digital cash, WeChat Pay, Alipay)
- Speech recognition
- Barcode reader (QR)
- Increase range of wireless services
    - WiMax
    - Peer to peer phones
- Integration with sensors
    - GPS, accelerometer, temperature,...
- Overcome limitations in screen size

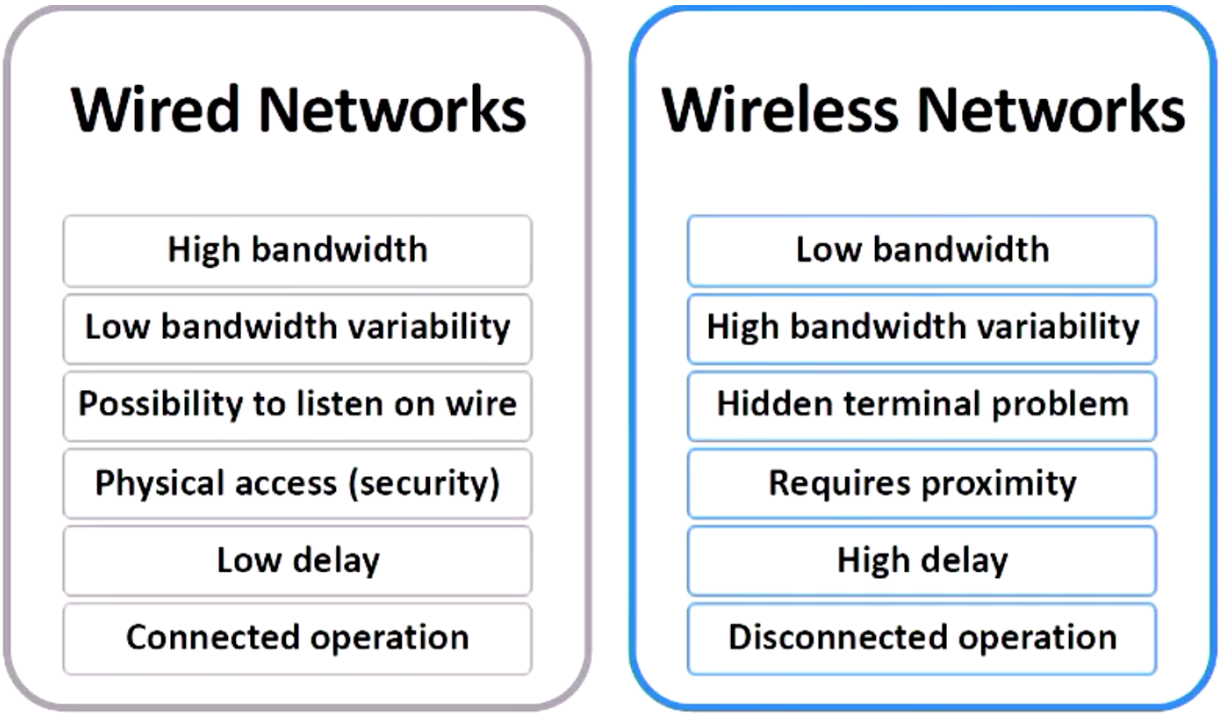
Operating Systems

- Symbian
- Windows Mobile
- Linux
- Palm OS (Dead now)
- RIM (BlackBerry)
- Android
    - Not an OS but a software stack that uses Linux
    - Dalvik virtual machine (Java)
    - WebKit (open source)
- iPhone OS

Challenages

(Wireless) Communication

- More frequent disconnections
- Lower bandwidth
- Higher Latency
- Variation in available bandwidth
- Complex network typology
- Increased risk



Mobility

- Address Migration
  - Mobile divices use different (IP) address
  - Selective broadcast, central services, home base, forwarding pointers
- Location Dependent Information
  - Information request depends on the location of devices
- Migration Locality
  - Connections should be automatically migrated to a closer server (geographically)

Portability

- Energy
  - Batteries - ~= 20% weights of a mobile device
  - Power consumption ~= CV^2F

        - C: capacitance can be reduced by **VLSI (??)** design
        - V: can be reduced by smaller structure
        - F: clock frequency
- Risk to data
    - easier to loos or damage in mobile devices
- Resource-poor related to static devices that have the same budget

Social Impact

- Privacy
- Security
- Behavior

Technologies

Physical

- WPAN (Bluetooth)
- WLAN
- WAN
- RFID
- GPS
- Routing in MANETs
- Mobile IP

Computing Paradigm

Developing Software

[++] Web vs Native

Web	Native
Create a web Service	Develop application via SDK
Client (include mobile device) access services via web browser	Deploy the app locally on a device and access services via apps
One code for all platforms	Each platform must be cared separately
Responsible Web Design(响应式设计)	
适用于: - 时间紧迫, 需要短时间内跨平台 - budget少的 - 互动不复杂的	适用于: - 对性能要求高的 - 使用很多sensors的

Design with all platforms considered

- High-level APIs
- Use platform-independent low-level APIs
- Responsiveness: Discover device capacities

[+++] UI Design and UX (User eXperience)

Principles

- KISS: keep it simple and stupid
    - simple and easy-to-use UI
    - Minimise user input
    - pre-selected likely choice
- Metaphors and skeuomorphism
    - 拟物风
- Material Design
- Use side drawers

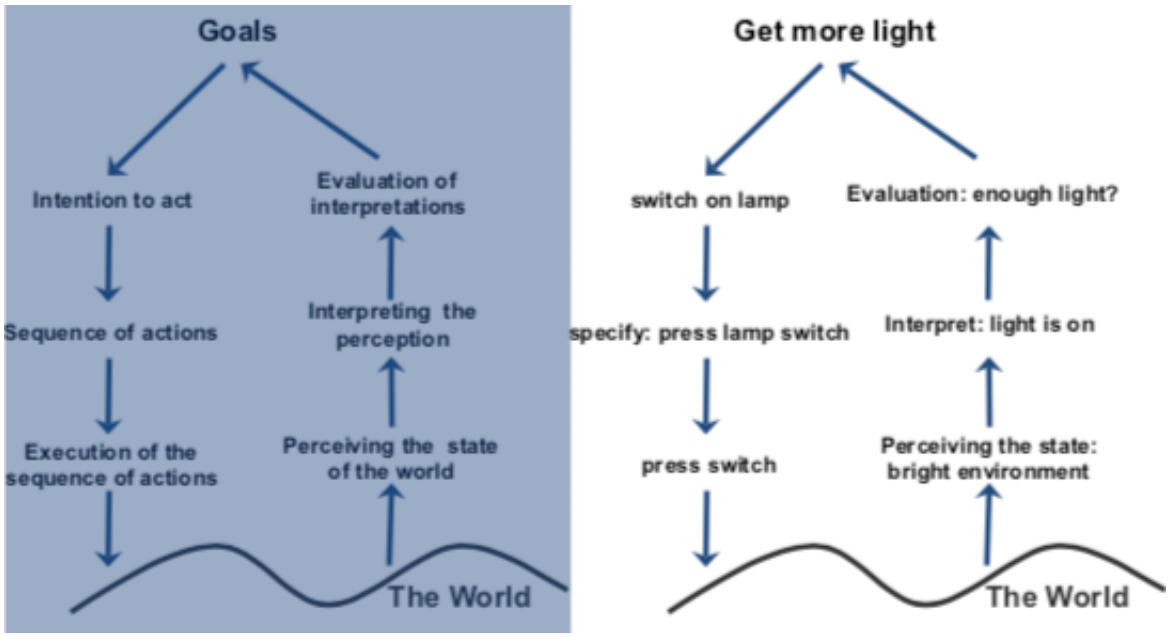
Tips

- Use side drawers (think off canvas)
- Springboards
- Card deck metaphor
- Dashboard

Design Cycle (steps)

7 Stages of Action

1. Find the goal
2. From goal to execution
3. (User) Evaluation the design
4. Improvement



Gulf (gap?) of Execution (执行偏差)

> 使用者规划的行动和系统所接受的不一致

- the difference between the intentions and the allowable actions
- how directly can the actions be accomplished
- Do the actions that can be taken in the system match the actions intended by the person

如何判断是不是好的Execution设计

> - user can tell what actions are possible
> - interface can help user map intention to physical movement
> - device can desily support required actions

Gulf (gap?) of Evaluation (评估偏差)

> 系统表现和使用者期待之间的差距

- workload to **interpret** the state of the system
- is the information easily accessible
- mismatch between the exception of users and the behovior of systems

如何判断是不是好的evaluation

> - user can easily tell if the system is in the desired state

> - user can map the system state to an interpretation
> - user can easily tell what state the system is in

UI Elements

Button, Stepper, Switch, Segmented, Checkbox, Popup Menu, (date) picker, UITextField, UITableView, UICollectionView, UILabel, UIImage

Text Input

- 12/9 buttons, QWERT keyboards, pen, voice, special hardwares
- Smart Watches: ZoomBoard, TouchOne, Touch-Sensitive Wristbands, Omnitouch

[++] Usability

Name	Description
Learnability	how easy for a user to learn
Efficiency	how quick can user perform a task
Memorability	how easy for a user to reuse it after quite a period of time
Errors	how to serve errors and how easy can user recover from errors
Satisfaction	how pleasant is it for user to user this design

Key points

Meet expectation:

- match between system and the real world
- Help and documentation
- Consistency and standards

User is the boss

- User control and freedom (makes people feel the control, like loading icons)
- Visibility of system status
- Flexibility and efficiency of use

Handle errors

- Error prevention
- Recognition rather than recall
- Help user recognize, diagnose and recover from errors

Keep is simple (and stupid, KISS)

- Aesthetic and minimalist design (beautiful and simple design)

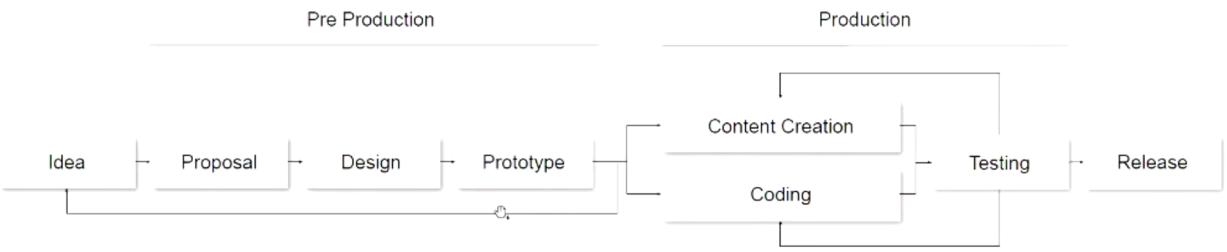
Game development Process

Classification Methods

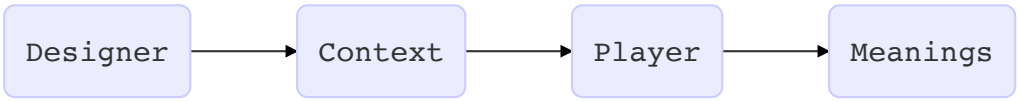
- Cooperation
- Sum of choice
    - Zero-sum/non-zero sum
- Simultaneous/Sequential (Turn-based)
- Information
    - Perfect (All known)
    - Imperfect
- By View(First-Person, Third-Person, side scroller)
- By Type (Action, Adventure, Puzzle)
- By genre(Fantasy, sport)

5 planes(factors) for a game

- rule-based
- medicated
- fictional
- play
- social



Game Design



Factors of a Game

Factors		
Semiotic	A symbol or icon that represents sth (objects, players, npcs)	
System	- **Objects**: parts/elements/variables that within the system - **Attributes**: qualities or properties of the system or its objects - **Internal** Relationships: relations between objects - **Environment**: context that surrounds the system	
Interactivity	- **Cognitive**: interpretive participation - **Founctional**: utilitarian participation - **Explicit**: participation with designed choices and procedures - **Beyond-the-object**: participation within the culture of the project	
Choices	- at micro level: each decision at its smallest level - at macro level: aggregated choices form a larger outcome - tactic (local planning): a cluster of choices - strategy (global planning): a sum of players' choices - outcomes depends on actions of the others (like your opponents)	

Implementing choices

- choice must have consequences (reflect for users' score or sth)
- avoid dominant choice
- cannot go back after consequences are applied

Importance of choices:

- critical: life or death
- important: direct or immedicate impact
- necessary: indriect or delayed impact
- minor: small impact (can be direct or indirect)
- without consequence

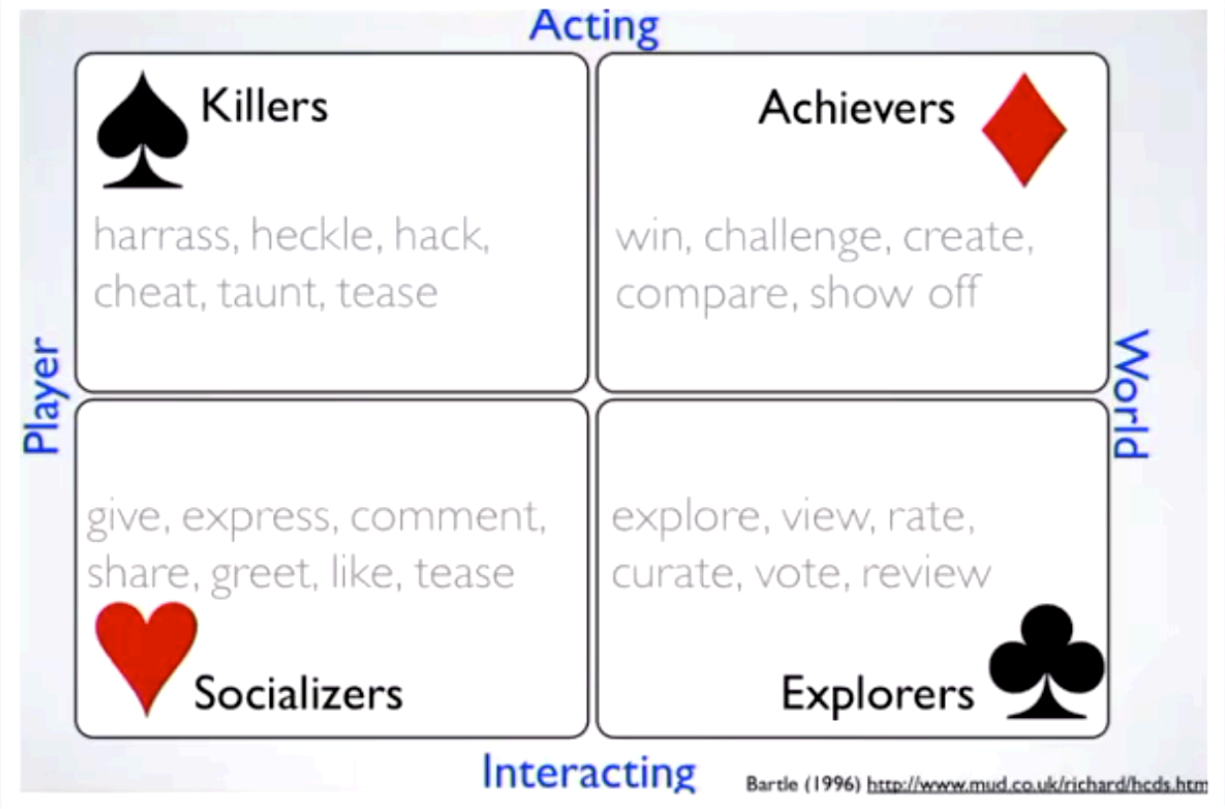
Frameworks

MDA (Mechanices, Dynamics, Aesthetics)

- **Mechanics**: Rules and algorithms define the actions
- **Dynamics**: Behaviour arising while players interact
- **Aesthetics**: Experiences, emotions

Player analysis

Player type (Bartle's Taxonomy of Player Type)



Game design criticals

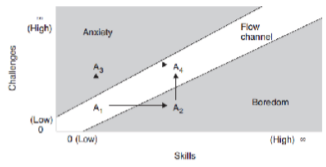
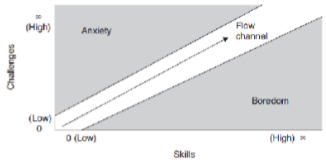
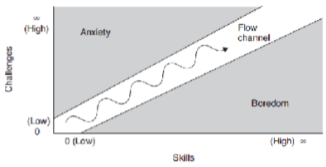
GDD	Game Design Document	
Expectations	What Players want and they do not	
Experience	Find an idea of a game with a meanful plot to convey an experience: - **idea**: goals, constaints,Rules, rewards, styles, ... - **meanful**: Location, age, world, universe - **plot**: Comedy, overcoming a master, Romance, ... - **convey**: impression, reaction, feedback	

[+?] The polt

- Experience should not be linear
- 情节循序渐进, 高潮迭起, 刺激不断

The flow

- 难易结合, 有难的篇章/操作,也有白痴/简单的篇章/操作

> flow of the game should be traded off between challenges and skills (of players)
>
> eg: (the white road is "**flow channel**")
>
> | Distractions, no flow | Flow, but too linear "run" | Most interesting flow |
> | --- | --- | --- |
> |  |  |  |

- Clear goals
- No distractions
- Direct feedback
- Continuously challenge

Rules & Goals

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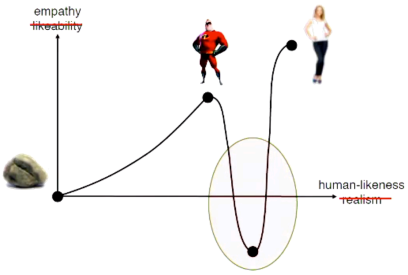
Aesthetics

Factors	Description
Style Guide	
Curves & Ratios	- Fibonacci Curves - Golden Ratio - Golden Angle - Voronoi Cells - Fractals, L-Systems - Flow Simulations
Colors	- Moodboards (mood board是指经由对使用对象与产品认知的色彩，影像，数字资产或其它材料的收集，可以引起某些情绪反应，作为设计方向与形式的参考。设计师运用它来检视色彩，样式，并据以说服其它人之所以如此设计的理由。其应用范围很广，可以用于接口设计，网页设计，品牌设计，营销沟通，电影制作，脚本设计，电玩游戏制作，甚至是绘图，室内设计等等。)

Realism

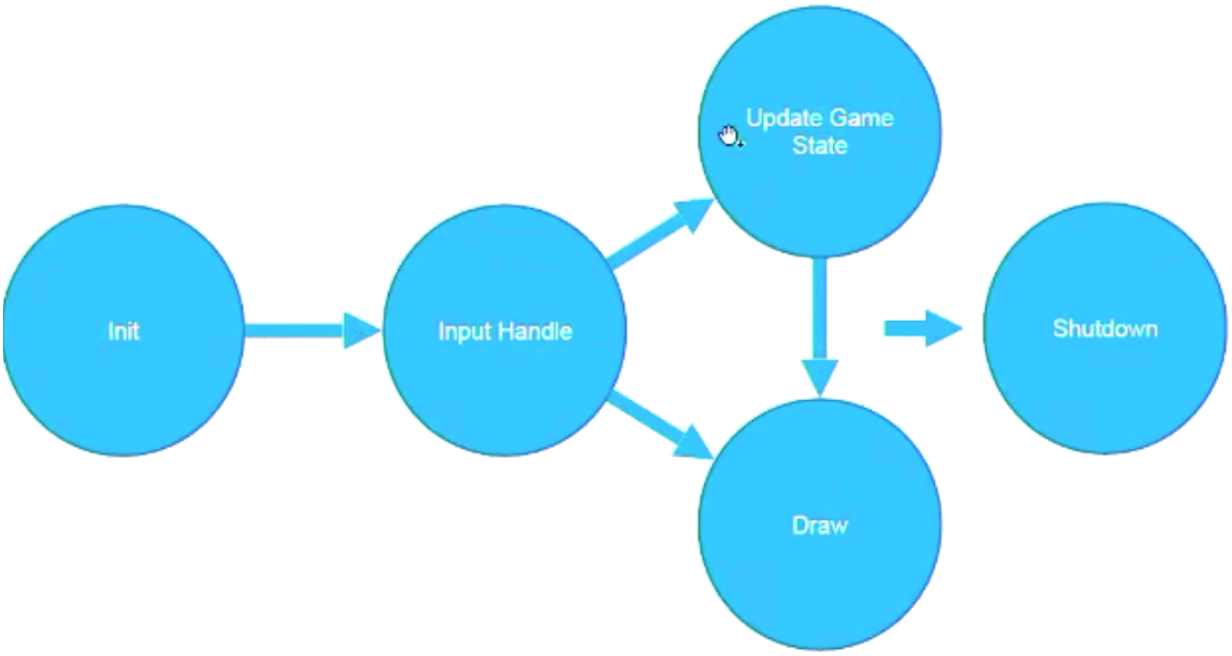
Problem: Uncanny Valley

人类(玩家)对机器人(游戏人物)在"拟人"水平达到100%之前的一小段时间突然产生强烈的厌烦.

Definition	Figure
恐怖谷現象可以用以下想法解释，如果一個实体「不够拟人」，那它的类人特征就會显眼并且容易辨认，产生移情作用。在另一方面，要是一個实体「足够拟人」，那它的非类人特征就會成为显眼的部份，在人类观察者眼中产生一种古怪的感觉.	

Game Technologies

Game Loop



Game API

Element	Description
GameCanvas	▪ Dedicated screen buffer (Graphics object) ▪ Supports incremental updates (instead of rendering entire frame) ▪ Flush graphics: display contents of the buffer
Layers	▪ Sprites and tiled layers ▪ Can be visible or invisible
Screen Buffer & Layers	
Sprites	A set of tiles is small; little memory required

Collision Detection

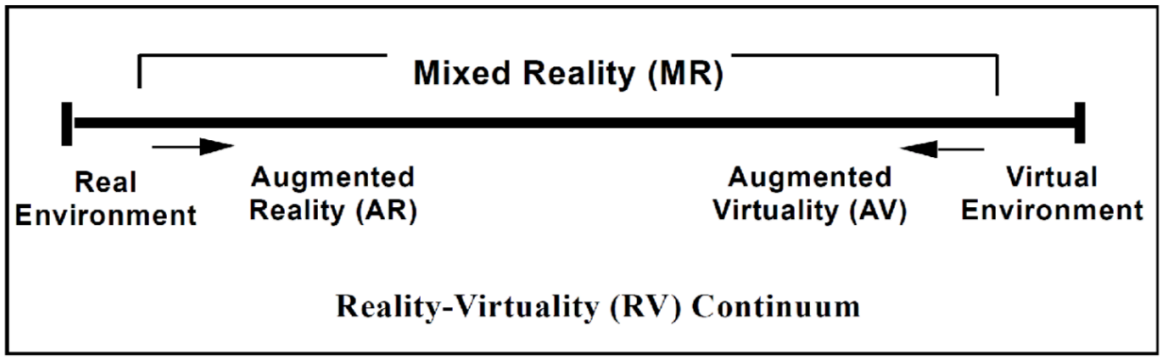
- Boundary-level (fast, like using a rectangle to represent a sprite)
- Pixel-levle (precise but resource-consumption)

Features of mobile games

Features	Description
Processing & Network	Less CPU power, (usually) no hardward acceleration, less memory, unstable networks
Hardware	Input capabilities, screen size - touch screen: feedback, adjustable
Portabality	**Sensors**: location, acceleration, camers **Context-awareness**: use environment as part of the game (AR) **Device as controller** Mixed reality games, location-based games

Augmented Reality (AR)

- Mixed Reality(MR)

> 
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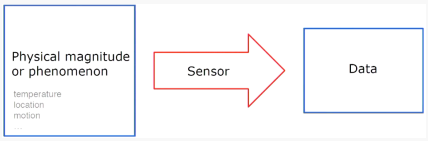
Sensors

Types		
Wearable Computing		
AR vs VR		
Internet of Things	- Reliable and effective for IoT (No) - Data privacy is an important problem (access easily granted,)	- Lightweight protocols - Network discovery - Scalability - Naming and addressing strategies - Dynamic routing
Sensors	In the broadest definition, a sensor is a **device, module, or subsystem** whose purpose is to **detect events or changes** in its environment and **send the information to other electronics**, frequently a computer processor.	 Camera, GPS, Accelerometer, Fingerprint, Ambient light sensor, Magnetometer, Microphone, Barometer
Context-Aware Computing	Such context-aware software adapts according to thelocation of use, the collection of nearby people, hosts, and accessible devices, as well as to changes to such things over time.	Eg: - An accelerometer to detect whether you are in a train, bus or car and do some task relevantly - light sensor (to adjust the light of the device itself) - Accelerometer for layout change(landscape or ...)

Location-based Services(LBS) & Location Privacy

Definition: Services that integrate a mobile's device location with other information

Push vs. Pull

- **Push**: User receives information without an active request
- **Pull**: User actively pulls information from the network

Location Accuracy Level of Applications

Accuracy Level	Applications
High Accuracy	- Asset tracking - Directions - Emergency
Medium to high accuracy	- Advertising - Car navigation - POI (point of interest)
Low accuracy	- Fleet management - News - Traffic Information

Location Engine

- Geocoding (translate street address to latitude & longitude or vice versa)
  - could be difficult if not complete information available
- Routing & Navigation
  - Compute best route: A*, Dijkstra...
  - Best could mean: shortest, fasterst, simplest,...
- Proximity search
  - Spatial DBs: POIs such as ATMs, hotels, gas stations,...

Location Privacy

- Location-based spam (email, ads)
  - Unsolicited advertising (Fackbook konws where you were !)
- Personal safety (celebrities positions were made public)
  - Stalking
  - Assault
- Intrusive inferences
  - Person's political views
  - Individual perferences
  - Health conditions

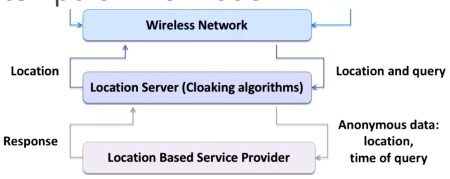
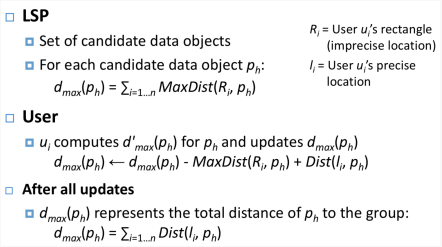
Sharing - Location obfuscate

Imperfect

- Types:

> **Types of imperfection**
>
> - Accurate and precise: $l \in O$ and $|O| = 1$
> - Inaccurate and precise: $l \notin O$ and $|O| = 1$
> - Accurate and imprecise: $l \in O$ and $|O| > 1$
> - Inaccurate and imprecise: $l \notin O$ and $|O| > 1$
>
> **Consequences**
>
> - The larger O, the less information is revealed about the true location l
>   - The greater the level of privacy
> - The greater the distance between O and the true location l
>   - The greater the level of privacy

[++] How to protect your location privacy

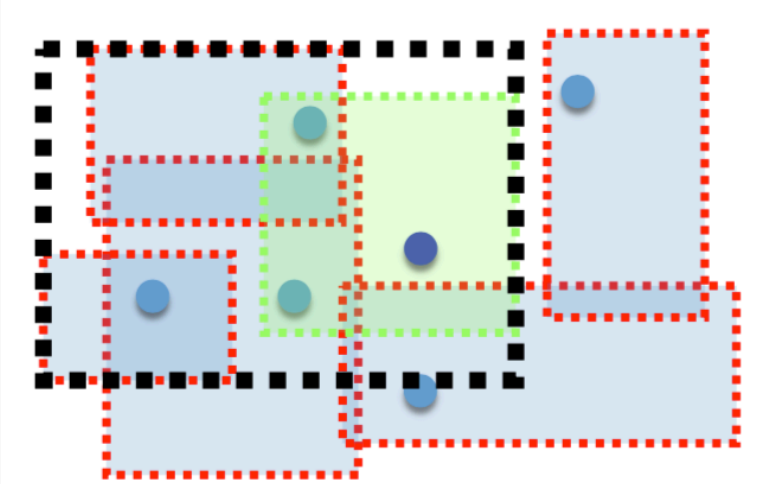
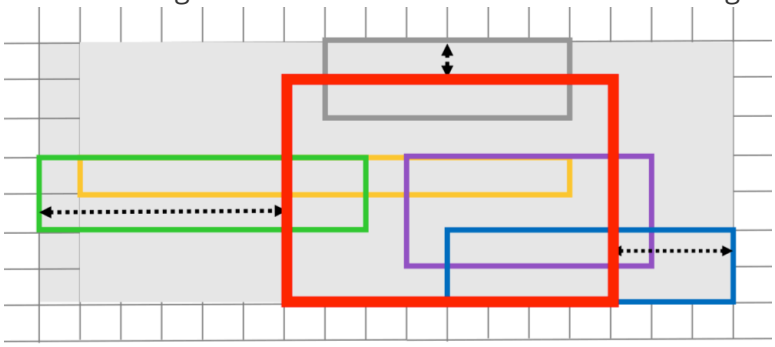
Method	Description	Comment
Stealth	Ability to be at a location without anyone knowing you are there (Use of passive devices such as GPS)	- Active devices such as mobile phones cannot preserve stealth - Access of information overrides stealth
K-Anonymity	https://www.zhihu.com/question/26710204 (k-anonymity指的是除非有k-1个人的数据同时被公布，才可能推断出第k个人是谁)	- quasi identifier
Cloaking	- 降低精度 - Reduce the frequency of temporal information 	- split people in the system, until we have ***k*** persons in an area and use that location to represent you (这样的话, 只有同时识别k-1个人是谁, 才能分辨出来你是哪个)
L-Diversity	- persons with same non-sensitive fields combination have different sensitive fields (增加数据的丰度,使得具有相同分类的non-sensitive出现尽可能多种类的sensitive)	
Decentralised	- limitations of centralised: communication overhead, security risks, single point of failure - LCA: locally cloaked area - GCA: globally cloaked area	See detail below
k-GNN	- find the place that sum the distances to all users of a group - **distance intersection attack**: if someone knows the distances from one user to 3+ places, then the accurate location of that user can be calculated out.(use aggregate information)	

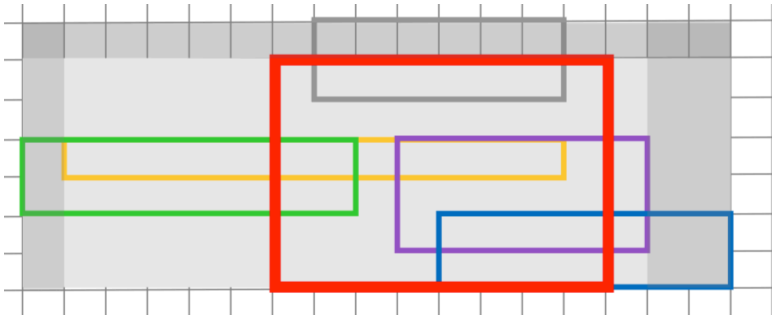
Decentralised

Principle:

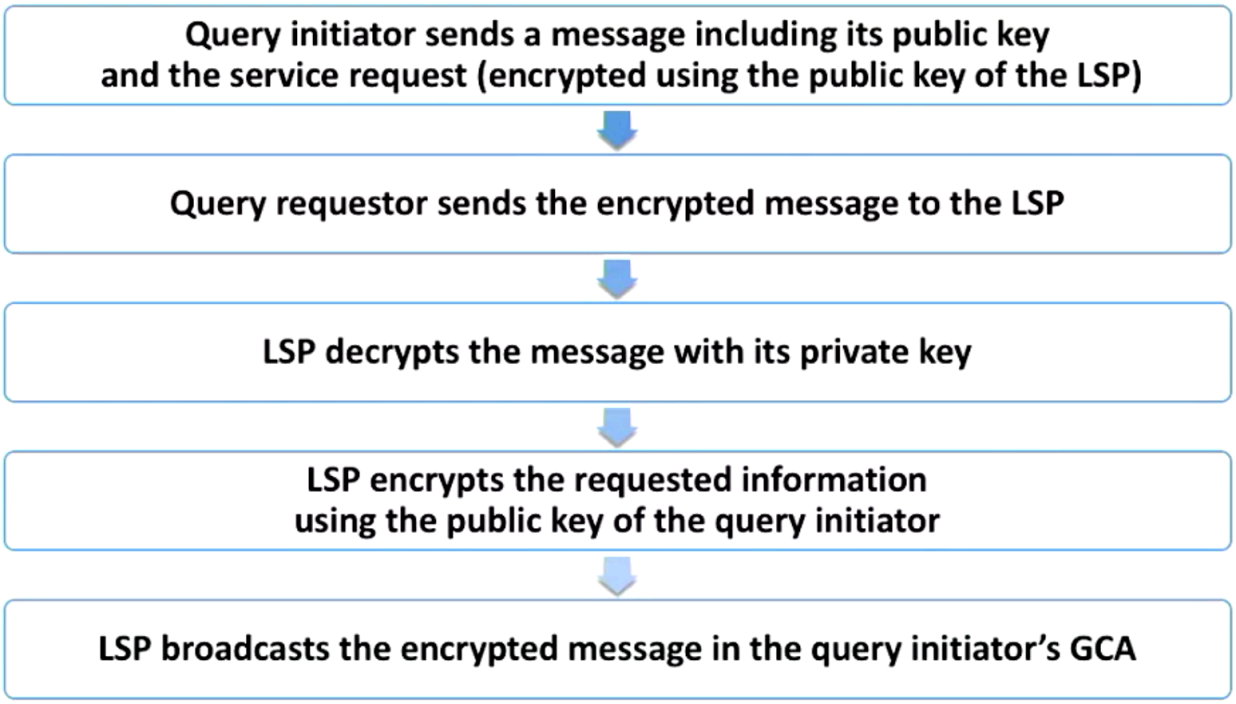
1. initiator: create request and encrypt request via public key (**using LCA to hide the precious location of itself**)

2. agent: initiator sends request to agent, agent sends it to LBS provider (**using GCA to decrease precious location of itself)**
3. LBS provider(eg, google): dencrypts the request and encrypts response via initiator's public key, and sends it to agent
4. agent sends responses to all devices of an area
5. only initiator can read the response (as only initiator has the private key to dencrypt the response)

LCA	locally cloaked area	- Parameter affecting ratio of length and width - Parameter for the agent's position relative to area's boundary
GCA	Globally Cloaked Area	Find the minimum bounding box of a k-subset (including the agent's own LCA) from n possible LCAs  - Green area is the LCA of the user - Dot black rectangle is the GCA
Approximating the GCA		- Red rectangle is the LCA - Whole grey area is different GCA stages 1. find the edge that has the max distance to the LCA edges  2. remove the rectangles which have the edges that selected from step 1 3. Find the GCA that can cover all left LCAs (white area as below).

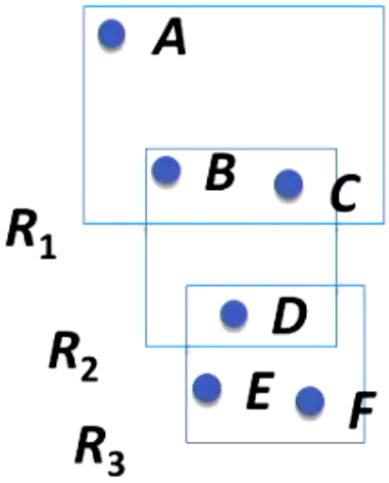
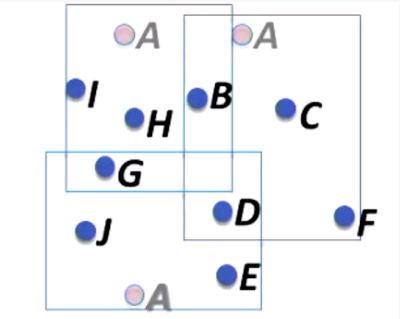
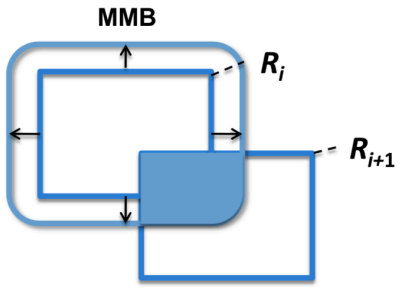
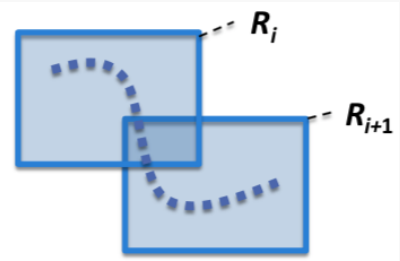
		
Random selection	How to select an agent	- Initiator selects one device A - Device A selects one device B - B actually sends the request

Whole step



Location attacks

Attack Type	Description	
		(User A can be easily outleted)

Query Sampling Attack	Can easily find a user (eg, A) from several different regions' user set information	
Query Tracking Attack	- Assumptions: continuous queries, some unchanged identity key - Track the path of a user, which may be used to find out the destination of that user (using intersection)	
Maximum Movement Boundary(MMB) Attack (a kind of query tracking attack)	- Assumptions: continuous queries, unchanged identity key between two consecutive queries - Can be used to fidn the approximate location of that user	
Query Trajectory Attack	- Assumptions: continuous queries, continuous updates to ensure result is correct - Can be used to intersect rectangles of two consecutive updates to refine the user location	
Context Inference(outdoor/indoor)	- to get the transportation of a user - prediction user's future route(based on history) - predict home address/current location - predict user's properties(age, work role, coffee/tea drinker, smoker...)	
Protect your trajectory	Moving kNN Queries - moving k nearest neighbours queries	parameters: - k: the bigger the less accurate

	- Risk: track user's trajectory	

Metrics for Location Privacy

Nouns	Definition	Comments
Anonymity Sets	The set of all possible subjects who might cause an action.	- The larger the size of the set, the greater the anonymity (eg, k-anonymity)
Obfuscation Sets	The locations from which a user's position is indistinguishable/indiscernable	- The larger the size of the set, the greater the location privacy
Distance Measures	Location privacy is the distance between a user's location	
Entropy(熵)		

Navigation under imprecision

Strategy	Solution Description	Comments
Contingency Strategy	1. 找到更可能的path 2. 尝试多条路线, 返回选择次数最多的routes	- in general, not the shortest path is selected - use Dijkstra

Negative Information

Negative representation of data

> Eg:
>
> 
> Given a set of 4 colors
>
> 
> Positive information: actual color of an object
>
> 
>
> Negative information: any color but the true color

Applications

- Discovering movement patterns in shopping malls
- Monitoring traffic
- Number of distinct entries to a shopping mall

- Traffic between two suburbs

RFID (radio frequency identification)

- Tag Types
  - Passive: No battery
  - Semi-passive: Circuit is battery-powered except communication
  - Active
- Reader: query tags via radio signals

Working steps

1. Reader (base station) sends a radio **interrogation signal**
2. RFID **tag** backscatters its ID
3. **Proximity-based** technology: determine the tag location by measuring the signal's **time of flight** (in theory)

Characteristics

- No **line-of sight** necessary (in contrast to barcodes)
- **Resist environmental conditions**: frost, heat, dirt, ...
- RFID **tags** with **read & write memory** (nonvolatile EEPROM)
- Smartcard functionality (JavaCard): **cryptographic** computations for personal contact cards
- Data Rate: 9.6 –115 kbit/s
- **Reader**: simultaneous detection of up to 256 tags, scanning of up to 40 tags per second
- **Response time** of an RFID tag: less than 100 milliseconds
- **ID**: 64, 96 , and up to 128 bits

Mode	Operation	Feature
Passive	- Do not need an internal power source - Operating power is **supplied by the reader** - Electrical current induced in the tag's antenna by the radio signal pulse of the reader	- Can be used for distances of **up to 3 meters** - Can be very small: 0.15 mm × 0.15 mm, 7.7µm thick (RFID powder, mu-chip from Hitachi) - Very **cheap** (a few cents)
Active	- Own power source (battery life expectancy: up to 10 years)	- Cost: a few dollars - Size: as small as a small coin - Support read ranges up to 100 meters - Deployment in more **difficult** RF situations (water) - Tags have typically **a higher scanning reliability** - Combination with sensors (vibration, light, humidity, ...)

RFID Frequency

Type	Range	Description
LF: low frequency	125 – 134.2 kHz, 140 – 148.5 kHz	- Good materials for water and metal (with hight go-through ability) - Widely adopted (and used longer than HF) - No collision protocol available (see later) - Typical read range: **30cm**
HF: high frequency	13.56 MHz	- Provides anti-collision protocols - Up to **1m** read range
UHF: ultra-high frequency	868 – 928 MHz	- Difficult to penetrate of water and metal (similar to light) - Read range: up to **3m**
Microwave or UWB	2.4 – 5.8 GHz or 3.1 – 10 GHz	- Read range: up to **2m** (projected up to **200m for UWB**) - High data rate

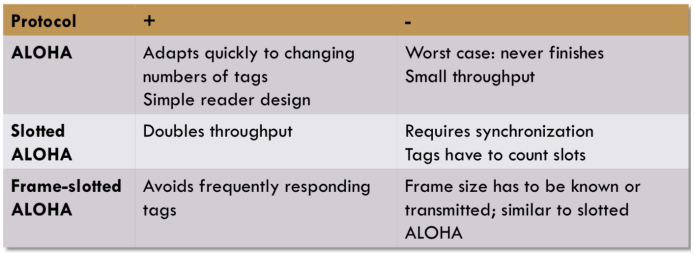
Anti-Collision & Singulation

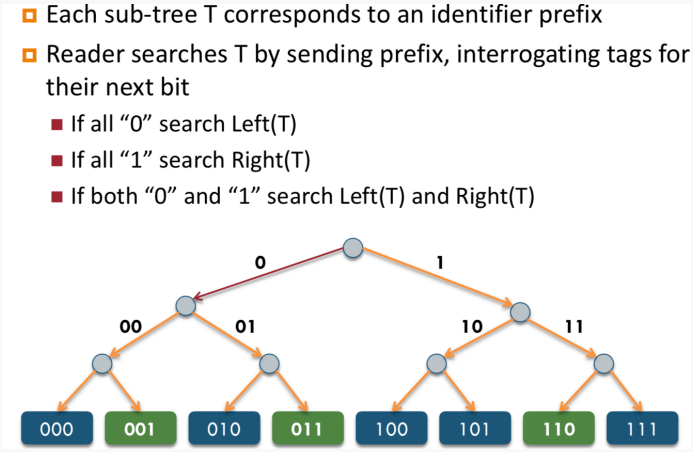
Used to solve collision problem (a read receives signal from sevaral different tags at the same time)

Anti-Collision: trade time for the possibility to interrogate all tags

Singulation: identify(iterate through) all tags

Protocols

Protocol	Comment 1	Comment 2
ALOHA	- **"Tag-Talks-First"** behavior: **tag** automatically sends its ID (and data) if it enters a **power field** - If a message **collides** with another transmission, **try resending** it later **after a random period** - Collision Types: Partial or Complete - throughput: **18.4%**	Reduce collision of ALOHA - **Switch-off**: After a successful transmission a tag enters the quiet state - **Slow down**: Reduce the frequency of tag responses - **Carrier sense** : 1. No carrier sense possible (tags cannot hear each other); 2.Use **ACK signal** of the reader in communication with another tag; 3.Reader **broadcasts** a **MUTE** command to other tags if it interrogates one tag
Slotted ALOHA	- **"Reader-Talks-First"**: Use discrete timeslots (SOF, EOF) - **A tag can only send at the start of a slot** - **only complete collision** - "Early end" - **throughput**: 36.8%	
Frame-slotted ALOHA	- Group several slots into frames - Only one tag transmission per frame - Limits frequently	

	responding tags - Adaptive version: adjust the number of slots per frame	
Binary Tree Protocol	- Tree traversal algorithm (**depth first search**) - "Reader Talks First", reader **boardcast** a request command with an ID as parameter - Only tages with lower or equal ID respond - tag is **remained quiet**(do no respond) if the tag is not the target one - **repeat** until no collision occurs or all tags are quiet	

Pros and Cons

Advantages	Disadvantages
Very cheap, high volume, large variety	No quality of service
Long industry experience	Only passive data acquisition (asymmetric communication)
Scanning even with high speeds possible (300km/h)	Possible interference with ISM bands
No maintenance, simple to manage	No authentication: - Readers can not sense tags if they do not reply - Tags reply to any reader
	No encryption: - Eavesdropping possible
	Man-in-the-middle attack

Applications

Summary

Type	Example	Risk
Alerting	- Payment: RFID smartcards and electronic toll collection	- Security risk: denial of service
Authentication	- E-passport and car keys	- Security risk: forgery
Identification	- Like barcodes but more data and faster to process	- Privacy risk: sniffing
Monitoring	- Product tracking and inventory management	- Privacy risk: tracking

Privacy

- Unauthorized surveillance/monitor
- Potential risks
    - mis-scanning high value goods

How to deal with them:

- Killing (tag deactivation)

    - damage the tags so that they cannot be used for furture usage (return defective goods, airline tickets)
- User intervention
    - Provide a button for user to press before reading tag(No protection against passive eavesdropping)
- Silencing: metal lining
    - Make radio of readers/tags do not work in some environment (RFID Blocking Passport Case)
- Active jamming
    - Device that broadcasts radio signals to block/disrupt RFID (make them unavailable)
- Hash-locking
    - lock tags with a mete ID y
    - unlock by a one-way function ($y=h(x)$)
    - Expensive since cryptographic operations are required
- Encrypting: silent tree walking
    - Encrypt readers transmission: a passive eavesdropper cannot infer the tag IDs
- One time identifiers (pseudonym rotation)
    - Works only for tree-based scanning algorithms
    - A blocker tag forces a reader to sweep the very large space of all possible tag identifiers
- HIdden-blocker tags (used to protect your bank card in your pocket)
- Keyless “Encryption”

RFID Authenticity

Threats

- Cloning: copying existing tags
- Forgery: creating new tags with a valid identity
- Relabeling

Track & trace

- Application anticipates tag movements, detects and reports anomalies and duplicates
- Can protect both threats but with hindsight (after bad things)

How to solve

- Static authentication
    - using digital signature
    - Protects against forgery, but not cloning
- Static authentication with public-key protocol
    - Tag authenticates reader by public-key protocol

    - Encrypts digital signature with reader’s public key

Security Schemes

- Rolling code schemes (cheap)
- Challenge-response protocols (expensive)

RFID Rights of consumers

- To know whether products contain RFID tags
- To have RFID tags removed or deactivated when they purchase products
- To use RFID-enabled services without RFID tags
- To access an RFID tag's stored data
- To know when, where and why the tags are being read

RFID Future Directions

- Super-distributed RFID infrastructures
    - Massive number of tags are placed on an object
    - Applications:
        - Indoor localization and positioning
        - Collaboration
        - Distributed storage of information

Networks

Benefits of Digital signals

- Efficiency
    - Higher data transfer than analog networks
    - Enables compression for higher efficiency
    - Smaller power consumption
- Security
    - Simple eavesdropping for analog signal (even for encrypted signals)
- Degradation and restoration (Error correction)
- Error detection
- Features

    - Caller ID and call answer, Data traffic

Switch

- Circuit switching
- Packet switching

Signal Propagation (distance ?)

- **Transmission range**: Communication with low errors
- **Detection range**: Detection but no communication (or with too many errors)
- **Interference range**: Signal cannot be detected or signal is part of the background noise

Issues in Wireless Transmission

- Problems for wave propagation
    - 反射(reflection): Large objects
    - scattering
    - 衍射:signal deviation (diffraction)
    - 折射:signal change and reflection (refraction)
- Multipath propagation
    - Signal takes different paths between sender and mobile device

[++] Multiplexing

Guard spaces

- Gap(can be time/frequency/code difference) between to two channels
- Reduce risk of interference between channels

Type	Definition	Advantages	Disadvantages
Space (SDM)		Space channels physically apart to avoid interference	Graph coloring problem(how to select channel between tow cells)
FDM	Frequency Division Multiplexing	- No dynamic coordination required - Can be used for analog networks	- waste of bandwidth if traffic distributed unevenly - Guard Spaces
TDM	Time Division Multiplexing - A channel gets the whole spectrum for a short time - All channels use same frequency at different times	- High throughput for many channels	- Precise clock synchronisation
Combine of FDM & TDM	Each channel gets a certain frequency band for a certain amount of time	- Higher data rate - more robust	- Precise clock synchronisation
CDM	Code Division Multiplexing - Each channel has a unique Code - Channels are separated by codes, with guard spaces	- No coordination and synchronisation is required - Bandwidth efficient	- Lower data rate

WPAN Standards

Body Area Networks

- Use natural electrical conductivity of the human body to transmit electronic data (2.4 KB/s up to 400 KB/s)
- Applications:
    - Car or phone recognizes a user
    - Pay by touching a device in a bus
    - Device configures itself through touch

Ultra Wide Band

- Radio always transmits at 640 Mbps but maximum actual data rate is 480 Mbps due to error correction
- Applications:
    - Short distance compressed video transmission

    - Wireless printing and monitors
    - [future] Precise location system and real time location system
    - [future] Precision radar imaging technology, even through walls
- Security
    - Stronger security than Bluetooth and WLAN
    - All devices have unique IDs
    - Cryptographic sequence number (avoid replay attack)

Bluetooth (802.15.1)

- Goal
    - **Ad-hoc** wireless connectivity for electronic devices
    - Low-cost replacement for wires
- Features
    - Short-range: 10 m – 100 m
- Networking
    - Point to point
    - Point to multipoint (up to 8 devices)
- Applications
    - Headsets for mobile phones
    - Game/remote controllers
    - Wireless keyboard/mouse
    - File transfoer for mobile devices
- Security
    - Authentication & data encryption
- Frequency hopping (跳频技术)
    - Packets are transmitted to a receiver over 79 hop frequencies in a pseudo random pattern
    - Transmitter switches hop frequencies 1,600 times per second
- Pairing
    - Share a passkey (stored in file system instead of bluetooth chip)
    - Device either requires pairing or asks whether a remote device can use its services
- Bluetooth vs. IrDA (infrared light)

	Bluetooth	IrDA
Obstacles	Radio waves penetrate obstacles	Light is blocked by obstacles
Alignment	Omni-directional	Narrow focused beam
Data rate	2 Mbps	1 – 4 Mbps
Range	10 – 100m	2m
Energy	More power	Less power
Price	Moderate ($10)	Cheap ($1)

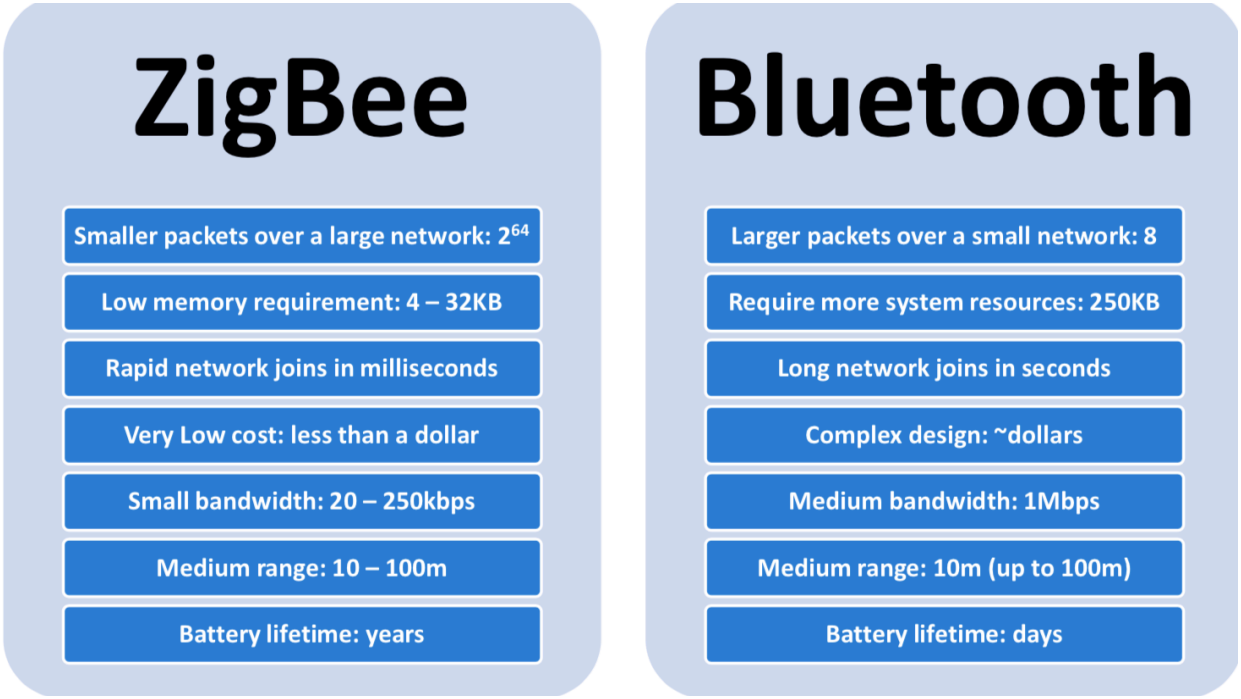
Piconets

- Ad-hoc network of up to 8 active devices (3 bits address space, so only 8 devices available)
  - One device acts as a master, the other devices as slaves
  - Each active slave has a 3-bit active member address; up to 7 active slaves
  - parked slaves: synced with master but **not active**
    - A parked device has an 8-bit parked member address; up to 255 parked slaves
- Scatternets
  - Connecting 2 (up to 10) piconets
  - A device acts a master in one piconet and as a slave in another piconet

ZigBee (802.15.4, low rate WPAN)

- Goal
  - Wireless standard for **sensing** and **control** applications
  - Highly **reliable** and **secure**, interoperable
- Features
  - Extremely low power (Designed for months to years on batteries)
  - 200 Kbps maximum
  - Huge address space (64 bit IEEE address)
  - 50m range (5-500m environment dependent)
- Used in:
  - Sensors, interactive toys, smart badges, remote controls, home automation
- Routing
  - **AODV**

Bluetooth vs. ZigBee



[+++] Routing

Routing Algorithms

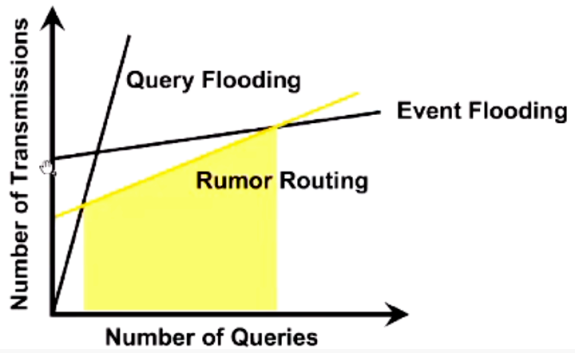
- Requirements
  - small routing table
  - Fastest, most reliable, highest throughput route
  - Nodes can die, join/move and leave anytime

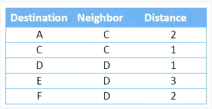
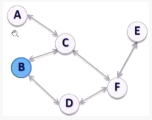
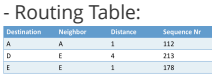
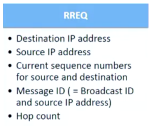
Architecture

- Layered architecture
- Flat architecture
- Hierarchical or clustered architecture

Protocols

Nouns	Description	Comment 1	Comment 2
Topology-based Rouing Protocol Categories	- **Proactve protocols** : Compute routes before routing - **Reactive protocols**: Discover routes on-demand - **Hybrid protocols** : Compute routes once, then update		
Flooding (routing)	Just broadcast (if not goal and TTL > 0) Reactive protocol	- simple	- waste resource - duplicate
Gossiping(limited broadcast)	broadcast only to a randomly selected neighbor	- less duplicates	- Long travel time for messages - No delivery

<table>
<tr><td></td><td></td><td></td><td>guarantee</td></tr>
<tr><td>Radius Growth</td><td>Smart version of flooding:
- with increasing TTL every round if destination is not found</td><td>- Try TTL = 1, 2, 3, ...</td><td></td></tr>
<tr><td>Source Routing</td><td>- source nodes store (only the ones they need) the path to destination</td><td></td><td>- not efficient if high mobility/ data rate</td></tr>
<tr><td>DSR (Dynamic Source Routing)</td><td>- like ARP or CMP in IP
- Cached routing
- discovery path via RREQ message (with address of S and D and a unique identification of this message)
- route maintenance: ACK, update routing table if error</td><td>Improvement:
- Caching of routes(DSR)
- Local search (flooding with TTL + 1)
- Hierarchy of nodes
- Clustering
- Implicit acknowledgment</td><td></td></tr>
<tr><td>Improving Source Routing</td><td>- Local search</td><td>- Caching of routes(DSR)</td><td></td></tr>
<tr><td>Directed Diffusion (DD)</td><td>- 一种基于查询的路由机制。汇聚(sink)节点通过兴趣消息(interest)发出查询任务，采用洪泛方式传播兴趣消息到整个区域的或部分区域内的所有传感器节点。兴趣消息用来表示查询的任务，表达网络用户对检测地区感兴趣的信息，例如检测区的温度、湿度和光照等环境信息。在兴趣消息传播的过程中，协议逐跳地在每个传感器节点上建立反向的从数据源到汇聚节点的数据传输梯度(gradient)。传感器节点将采集到的数据沿着梯度方向传送到汇聚节点。
- 定向扩散协议的任务是在传感器节点和sink节点之间建立梯度，以便可靠地传递数据。
https://baike.baidu.com/item/定向扩散路由</td><td>- Interest Propagation
- Data Propagation
- Reinforcement (加强一条可用路线)
- Negative Reinforcement (切断错误加强的路线, 或者time out的路线)
-Extension: push diffusion (data from source actively)</td><td></td></tr>
<tr><td>DD Detail</td><td><table><tr><th>Diffusion Element</th><th>Design Choices</th></tr><tr><td>Interest Propagation</td><td>• Flooding
• Constrained or directional flooding based on location
• Directional propagation based on previously cached data</td></tr><tr><td>Data Propagation</td><td>• Reinforcement to single path delivery
• Multipath delivery with selective quality along different paths
• Multipath delivery with probabilistic forwarding</td></tr><tr><td>Data Caching and Aggregation</td><td>• For robust data delivery in the face of node failure
• For coordinated sensing and data reduction
• For directing interests</td></tr><tr><td>Reinforcement</td><td>• Rules for deciding when to reinforce
• Rules for how many neighbors to reinforce
• Negative reinforcement mechanisms and rules</td></tr></table></td><td></td><td></td></tr>
<tr><td>Rumor Routing</td><td>- agent based
- developed from DD
- used for small data transmission
- random send request instead of boardcasting (so route is not optimal)
- Query flooding(good for small count of queries) & event flooding(good for large count of queries)
  </td><td>- low cost for building routing</td><td>- longer delay than DD
- no deliver guarantee
- performance depend on toplogoy</td></tr>
<tr><td></td><td>- Goal: Minimize energy dissipation in SNs</td><td></td><td>- “Hot Spot” Problem: congested, some node</td></tr>
</table>

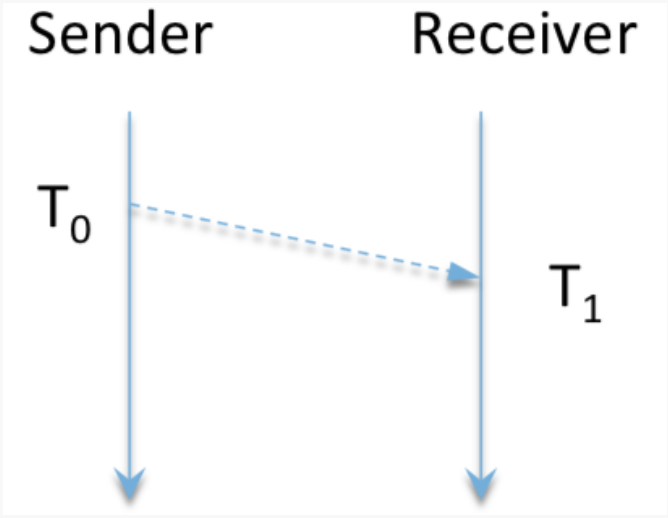
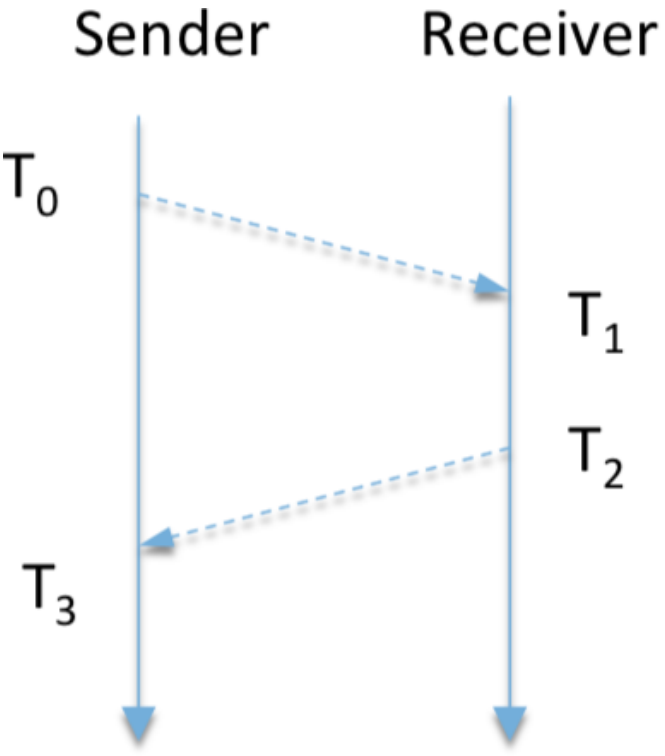
LEACH(**Low-Energy Adaptive Clustering Hierarchy**)	- Architecture: Hierarchical protocol (randomly select node as cluster head and reselect periodically) - States: **set-up** state(short, **select CH, CH boardcasts, Schedule Creation**), **steady state**(long, for data transmission via **TDMA in same cluster**) - different **CDMA** codes for different clusters - Only CHs communicate with sink		becomes too busy - Stationary Sink (May be unpractical,) - 1 hop neighbors(some node may not belong to any cluster?)
Distance Vector Routing (a kind of route protocol)	- proactive protocols - each node has a routing table - sync routing table with neighbours	 Destination Neighbor Distance A C 2 C C 1 D D 1 E D 3 F D 2	
[-] AODV (ad-hoc on-demand DV) for **ZigBee**	- reactive protocol - **RREQ**: message to discover destination(route) - **RREP**: message to reply - **RRER**: error message	- Routing Table:  Destination Neighbor Distance Sequence Nr A A 1 112 D E 4 213 E E 1 178	
TEEN (Threshold senstive energy efficient network)	- reactive protocol - 持续监控,但是仅在数值突变时(主动)发送数据	- good for time critical-applications - less energy consumption	- not good for periodic monitor - cannot detect important lost data
APTEEN (AdaPtive)	- extent TEEN to support both periodic and non-periodic (by sending data if no data was sent during the past **period** of time)	- less energy than LEACH but more than TEEN	
SPIN (Sensor protocols for information via Negotiation)	一种以数据为中心的自适应通信路由协议。它通过使用节点间的协商制度和资源自适应机制，解决了传统协议所存在的内爆，重叠以及盲目使用资源问题。 SPIN协议有 3 种数据包类型，即 ADV、REQ 和 DATA。 - **ADV** 用于元数据的广播 - **REQ** 用于请求发送数据 - **DATA** 为传感器采集的数据包	- send metadata pacakge(ADV) first, who interests send REQ to the sensor for that data - save energy	
SPIN-metadata SPIN-1 SPIN-2			

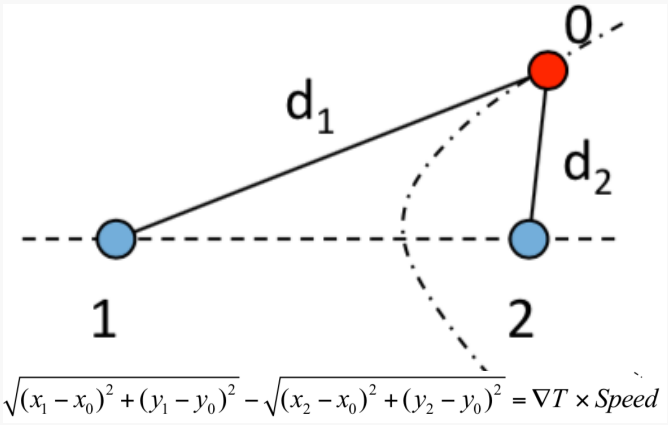
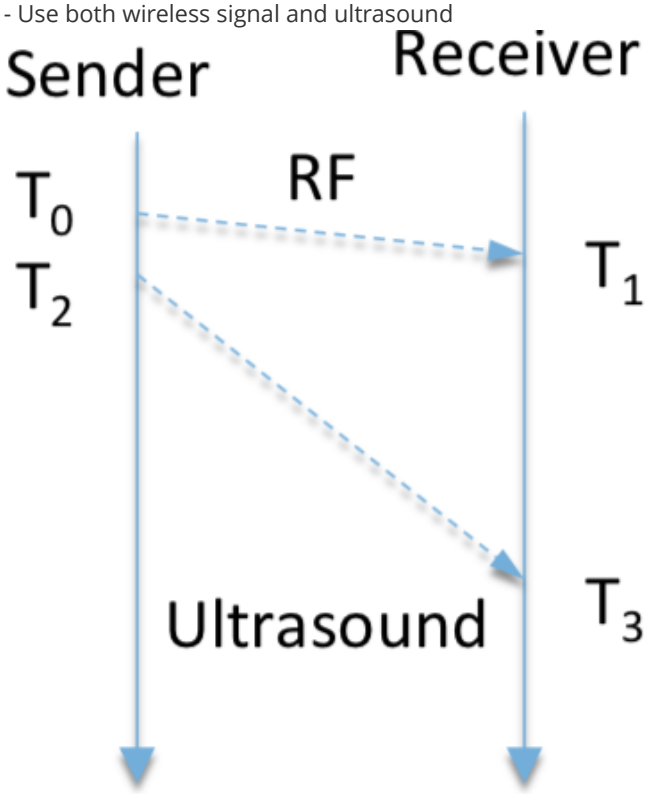
Sensor Localisation

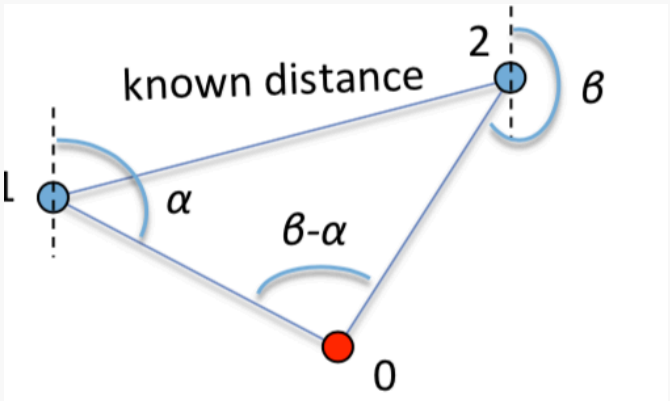
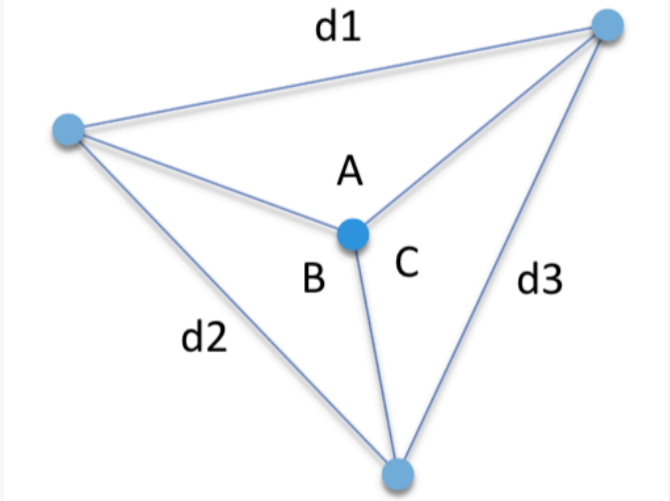
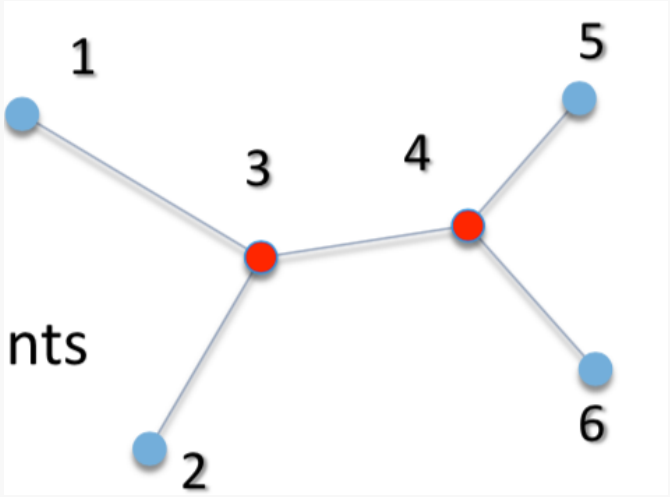
Range-based methods

- Absolute point-to-point distance estimates
- Angle estimates
- Atomic multilateration
    - Compute a node's location from 3 or more landmarks using distances

Method to		

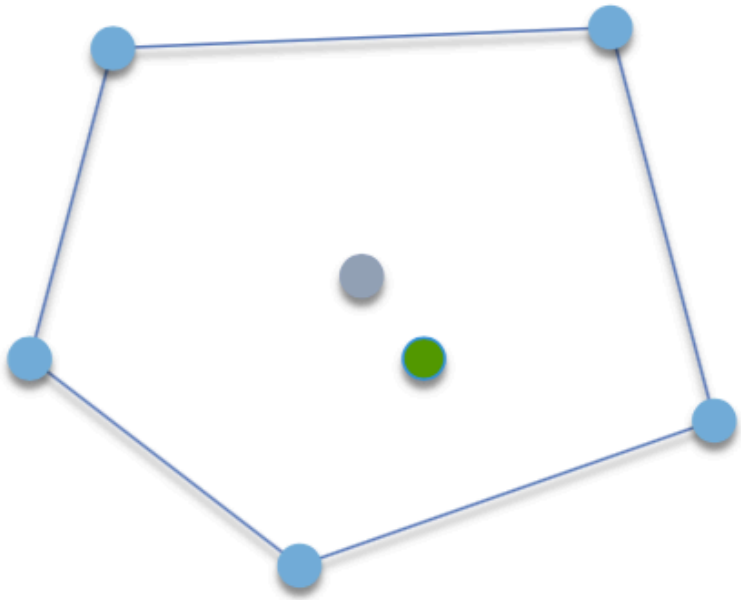
get distance	Comment 1	Comment 2
Received Signal Strength Inverse (RSSI)	Path loss model $$P_{RX} = c \times \frac{P_{TX}}{d^{\alpha}}$$	Simple, but **unreliable** due to **inaccurate** range estimates
One Way TOA (Time On Arrival)	 $Distance = (T_1 - T_0) * speed$	- accurate: about 10cm - range: ten of meters - need time sync between two nodes
Round-trip TOA		- No time synchronization required
Same	Use two receivers and measure me difference to estimate the difference in distance	

Frequency TDOA (Time Difference on Arrival)		- calibration
Different Frequencies TDOA	- Use both wireless signal and ultrasound 	- Problem: Hardware cost
AOA (Angle		Unrealistic for most of WSN applications due to complex hardware

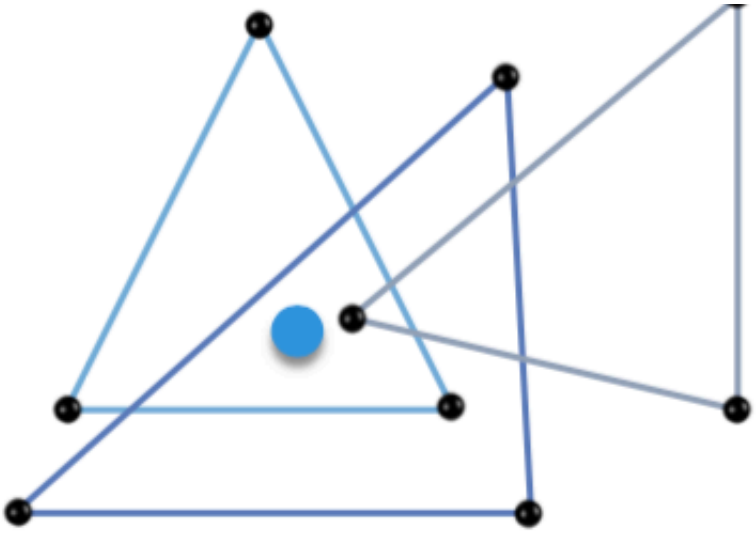
on Arrival)	 	and AOA estimation algorithms (不好测量, 还难算)
多边形计算		
Collaborative Mul/lateration	- 当多个相邻的节点都不是konwn的, 并且每个节点都不能发现 3+ known nodes - 使用方程组,一起解 	更难算了

Range-free methods

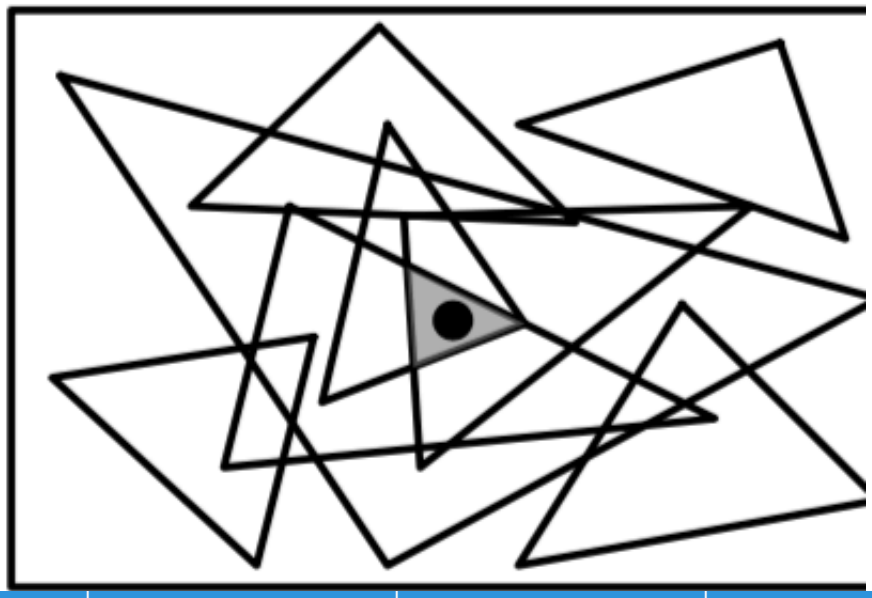
- more cost-effec$ve than range-based methods
- less accurate than range-based methods

Method	Comment 1	Comment 2
Centroid Approach		 $(x, y) = (\frac{\sum_i^N x_i}{N}, \frac{\sum_i^N y_i}{N})$ 包围这个unkown node的known nodes的平均值
DV-Hop (Distance Vector Hop)	使用Hop估算distance, 然后算location	

| APIT (Approximate Point in Triangle) | - area based algorithm
- intersection of all triangles
- PIT theory (If there is a direcHon in which M is moves away from points A, B, and C simultaneously, then M is outside of ΔABC; otherwise, M is inside ΔABC.)

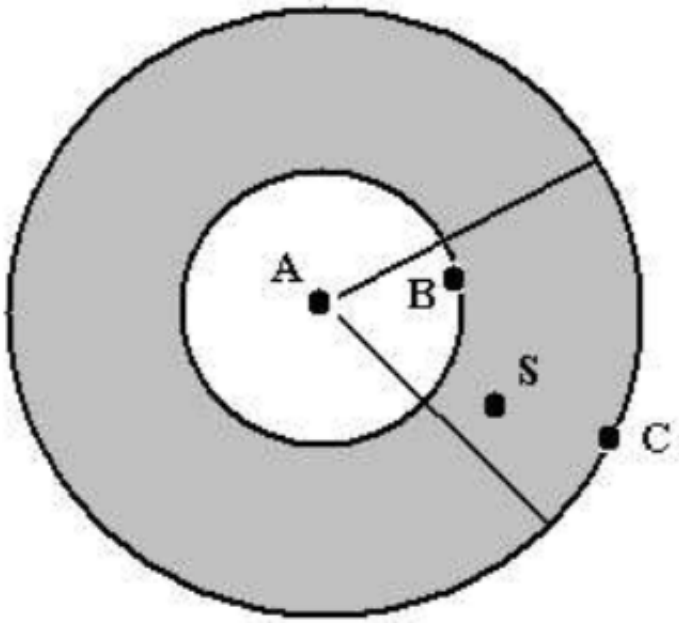


- anchor tables | | | |



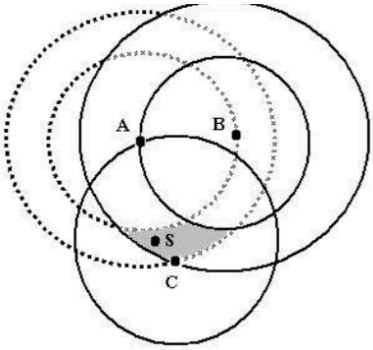
	Centroid	DV-Hop	APIT
Accuracy	Fair	Good	Good
Node Density	> 0	> 8	> 6
Anchor	> 10	> 8	> 10
Anchor to Node Ratio	> 0	> 0	> 3
Degree of Irregularity	Good	Good	Good
GPS Error of Anchors	Good	Good	Good
Overhead	Smallest	Largest	Small

| | | ROCRSSI | - If B's RSSI < S's RSSI < C's RSSI
- Then S is in ring



|

- ROCRSSI only compares the relative strength of RSS
- Compute ring for each anchor S can hear
- Center of gravity of intersection of rings is S's position



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Location Verification

SerLoc (via Different Frequencies TDOA)

Idea: 跟verifier确认位置, 使用 Different frequencies TDOA

Weaknesses

- Requires extra hardware, i.e., ultrasonic channel
- Valid nodes may respond late due to backlog
- Not loca/on verifica/on but range verifica/on!