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Abstract: [Classification of ranging services based on index parameters]

Purpose: [To propose a classification of ranging services for 802.15.4a]

On Classification of Ranging Services

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Outline

- Review: current classes of ranging services
- Our proposal
  - Motivation
  - Description
- How to represent mobility?
- Conclusions

Review: Current Classes of Services (doc. 0221-01)

- Accurate ranging
  - < 25cm, 50m, 4ms
- Fast ranging
  - < 25cm, 20m, 500us
- Cost-effective ranging
  - <1m, 20m, 4ms

  All effective for 90% of channels

Three Index Parameters

- Ranging accuracy
  - High: 25cm (margin for positioning, GDOP 4)
- Ranging distance
  - 20m, 50m
- Ranging time
  - Fast: 500us (margin for positioning where multiple nodes are involved)

Review: Communication and Ranging

- Parallel mode (current)

  In order to achieve an independent throughput for communication, generally, communication and ranging are done in parallel.
- Separate mode(to be discussed)

  In case a high accuracy ranging is required, a separate mode using longer preamble and/or high SNR is available.

Our Motivation

Flexibility to accommodate

1. More potential applications
2. Communication data

- Classification based on index parameters
- Addressing mobility
- Enhancement mode

A Classification of Ranging Service based on Index Parameters

Accuracy		Distance		Mobility		Enhance-ment Option
High	Normal	Long	Normal	Fast	Normal	1. Whether communication data utilized? 2. Longer preamble?
<25cm	<1m	<50m	<20m	>10m/s (or 36km/h), <0.1s update period	<10m/s, >1s update period	

All numbers are effective in 90% of channels

Red color parts : difference from the current classification (document 0221-01).

What's new (1): based on index parameters

- 2^4=16 possible classes (combinations)
  - e.g., an accurate fast ranging in a normal distance without enhancement
    i.e., error<25cm, speed<10m/s, within 20m, using a normal preamble only
  - some of combinations may not be practical
- The numbers in each category open for discussion.
  - ``accuracy" and ``distance" categories come from document 0221-01.

What's new (2): Enhancement Mode

- Using longer preambles
- Using communication data
  - **Pros**: improved ranging accuracy, less constraint on the preamble
    - Rationale: more symbols for ranging
  - **Cons:** increased complexity, longer processing time
  - Supporting research available: joint channel estimation and data extraction

Other enhancement technologies?

Comparison

Communication and Ranging

- Parallel mode (**current**)
- Collaboration/enhancement mode (**new**)

What's new (3): Mobility

How to better represent mobility?

- Speed (straightforward)
- Update period (limiting on-air traffic)
- Ranging time (not strictly constrained by mobility)

Update Period: limiting on-air traffic

- Mobility vs. update period

$$T = \frac{L}{v},$$

  - T= ranging update period, v=node speed
  - L= maximum distance allowed between two consecutive ranging estimates

An example: $L=1$m, $v=3$m/s, ➔ $T<333$ms.

- Also depending on specific applications
  -- e.g., how many visitors coming to an exhibition, T=1s

On Ranging Processing Time (1)

Mobility vs. ranging time

$$T < \frac{a \cdot e}{v},$$

- *e*=ranging error,
  v=node speed,
  a=maximum percentage of error increase due to the mobility,
  e.g., *a*=10%, *e*=25cm, total error *(1+a)e*=27.5cm

- E.g., *v*=10m/s, *a*=10%, *e*=25cm ➔ *T*<2.5ms

Mobility places less constraint on ranging time.

On Ranging Processing Time (2)

Mainly constrained by

- Positioning schemes, e.g.,
  - the anchor-based positioning:
    ~ one ranging (processing) time
  - the moving node-based positioning
    ~ no. of anchor nodes * one ranging (processing) time
- Whether enhancement technologies adopted
  - e.g., using communication data

Concluding Remarks

- A classification based on index numbers
- Representing mobility
- Including enhancement possibility

Appendix

Classification on ranging services in sensor network

NOTE: This is a modified version of a document issued by the

Ministry of Internal Affairs and Communications, Japan.

(http://www.soumu.go.jp/s-news/2004/040806_4_b2.html)

Application of positional detection in sensor network (1/ 8)

Field	Application	Example of using Ranging	Cover Range	Positioning Accuracy	Distance Resolution	Mobility of movement object	Mobility of measurement side	Update period
Disaster prevention and forecast	The sensor is scattered, damage by a flood, a forests and fields fire, the earth and sand collapse, and liquidizing, etc. are detected, and the natural damage is forecast.	Positional confirmation when scatter sensor is installed and after it sets it up, a positional change is observed.	100m ～	3m	1m	1 km/h	0 km/h	10min
	The situation of the site of the disaster of a fire etc. (temperature, smoke, poisonous fumes, and building collapse, etc.) is perceived, and it fights a fire and it supports it the rescue operation.	Positional confirmation when sensor is installed. Fireman's position is confirmed.	30m	1m	30cm	3 km/h	0 km/h	1s
	The victim of a fire etc. at the disaster in the town and rescue person's position are confirmed, and it induces it the escape route.	Real-time, positional confirmation of person	30m	1m	30cm	3 km/h	0 km/h	1s

Long Middle Low

Application of positional detection in sensor network (2/8)

Field	Application	Example of using Ranging	Cover Range	Positioning Accuracy	Distance Resolution	Mobility of movement object	Mobility of measurement side	Update period
Crime prevention and security	Person's movement is perceived with the sensor, and an illegal invasion is detected.	Positional confirmation when sensor is installed	30m	30cm	10cm	3 km/h	0 km/h	1s
	Management of insertion leaving a room with tag.	Real-time, positional confirmation of tag	10m	30cm	10cm	3 km/h	0 km/h	1s
	Anti-theft of valuables	Real-time, positional confirmation of tag	5m	10cm	3cm	1 km/h	0 km/h	1min
Food and agriculture	Sunshiny and precipitation, etc. are detected with the sensor installed on the farm, and the promotion environment is optimized.	Positional confirmation when sensor is installed	100m ～	10m	1m	0 km/h	0 km/h	1day
Environmental preservation	Nox and other Sox harmful gases, etc. are detected, and air pollution etc. are monitored.	Positional confirmation when sensor is installed	100m ～	10m	1m	0 km/h	0 km/h	1day

Long Middle Low

Application of positional detection in sensor network (3/ 8)

Field	Application	Example of using Ranging	Cover Range	Positioning Accuracy	Distance Resolution	Mobility of movement object	Mobility of measurement side	Update period
Medical treatment and welfare	A daily health care and it informs in the emergency the monitor of the vital sensor (momentum, pulse, and blood sugar level, etc.) put up to the person.	Momentum confirmation from person's real-time, positional confirmation and position	30m	1m	30cm	40 km/h	0 km/h	0.1s
	The senior citizen's behavior is observed, and a positional confirmation when wandering and the emergency call in abnormal circumstances.	Real-time, positional confirmation of senior citizen	100m ～	1m	30cm	3 km/h	0 km/h	1s
	It automatic records on the care card and the medical error is prevented the confirmation of the position of the medical treatment staff, the patient, and medical equipment in the hospital.	Real-time, positional confirmation of medical treatment Staff, patient, and medical equipment	30m	30cm	10cm	3 km/h	0 km/h	1s

Long Middle Low

Application of positional detection in sensor network (4/8)

Field	Application	Example of using Ranging	Cover Range	Positioning Accuracy	Distance Resolution	Mobility of movement object	Mobility of measurement side	Update period
Facilities control	It is comfortable and achieves it conservation of energy by the grasp of person ‘s location information, and the illumination and the air-conditioning only of a necessary part.	Real-time, positional confirmation of person and sensor	30m	1m	30cm	3 km/h	0 km/h	1s
Clerical work and business	Management of the insertion leaving a room and it manages working management the confirmation of employee’s position and situation with a portable device and the sensor.	Real-time, positional confirmation of employee	30m	30cm	10cm	3 km/h	0 km/h	1s
	Security and it achieves it conservation of energy according to automatic log in and the logoff of PC responding to PC and user’s positions.	Real-time, relative, positional confirmation of PC and user	10m	30cm	10cm	0.1 km/h	0 km/h	1s

Long Middle Low

Application of positional detection in sensor network (5/8)

Field	Application	Example of using Ranging	Cover Range	Positioning Accuracy	Distance Resolution	Mobility of movement object	Mobility of measurement side	Update period
Traffic	Congestion information is detected with the sensor installed on the road, and it eases it congestion because of an appropriate route guide.	Positional confirmation when sensor is installed	100m ～	1m	30cm	0 km/h	0 km/h	1day
	The prevention of accidents the state of the road is detected with the temperature and the frozen sensor installed on the road, and it informs the driver.	Positional confirmation when sensor is installed	100m ～	1m	30cm	0 km/h	0 km/h	1day
	The pedestrian accident is prevented the confirmation of a relative position of the pedestrian and the car.	Pedestrian and real-time, relative, positional confirmation of car	100m	30cm	10cm	3 km/h	～ 30 km/h	0.01s
Structure management	Damage and the deterioration of the structures such as buildings and bridges are monitored with various sensors (vibration and pressure, etc.), and it prevents it the disaster.	Positional confirmation when sensor is installed	100m ～	1m	30cm	0 km/h	0 km/h	1day

Long Middle Low

Application of positional detection in sensor network (6/8)

Field	Application	Example of using Ranging	Cover Range	Positioning Accuracy	Distance Resolution	Mobility of movement object	Mobility of measurement side	Update period
Distribution and marketing	Customer (shopping cart) movement in the shop is detected, and the marketing disseminations of the commodity array and goods in stock, etc.	Customer's (wagon) real-time, positional confirmation	30m	30cm	10cm	3 km/h	0 km/h	1s
	The position of customer and customer's terminals in the shop is detected, and the sales promotion by customer's position and the product dissemination which suits one's taste.	Real-time, positional confirmation of customer and customer premises equipment	30m	30cm	10cm	3 km/h	0 km/h	1s
	It delivers the best and it manages from the history the detection of the keeping situation of the commodity (temperature, humidity, and vibration, etc.) with the sensor.	Occasional positional confirmation of commodity	30m	30cm	10cm	0.1 km/h	0 km/h	1min

Long Middle Low

Application of positional detection in sensor network (7/8)

Field	Application	Example of using Ranging	Cover Range	Positioning Accuracy	Distance Resolution	Mobility of movement object	Mobility of measurement side	Update period
Distribution and marketing	The position of luggage in the warehouse is confirmed and the efficiency improvement of distribution.	Occasional positional confirmation of luggage	30m	30cm	10cm	0.1 km/h	0 km/h	1day
	Car position confirmation in used car place	Occasional positional confirmation of car	300m	3m	1m	0.1 km/h	0 km/h	1h
	Positional confirmation of stray child such as shopping centers	Occasional positional confirmation of stray child	100m	3m	1m	3 km/h	0 km/h	1s
	The positions such as a product, self-propelled cars, and tools in the factory are confirmed and production management.	Real-time, positional confirmations such as products and self-propelled cars	100m	30cm	10cm	3 km/h	0 km/h	1s
Information appliances	The situation of the viewer and the room is confirmed with the sensor, and the optimum control theories of the volume and the image, etc.	Real-time, positional confirmation of viewer	10m	30cm	30cm	1 km/h	0 km/h	1s

Long Middle Low

Application of positional detection in sensor network (8/ 8)

Field	Application	Example of using Ranging	Cover Range	Positioning Accuracy	Distance Resolution	Mobility of movement object	Mobility of measurement side	Update period
Education and study	Detailed guide and route guide in museum, museum, exhibition, zoo, aquarium, and amusement park, etc. according to position of visitor and terminal	Real-time, positional confirmation of visitor and terminal	30m	1m	30cm	2 km/h	0 km/h	1s
	Lesson guidance which confirms movement of body in sports of golf etc.	Real-time, relative, positional confirmation of body, foot, and hand	3m	3cm	1cm	36 km/h	0 km/h	0.01s
	Players of golf and baseball, etc. in sports and the positions of the ball are confirmed, and the automatic tracking of the strategy plan and the camera.	Player and real-time, positional confirmation of ball	300m	30cm	10cm	150 km/h	0 km/h	0.1s
Others	Place confirmation of lost article of valuables etc. in room etc.	Occasional positional confirmation of valuables	10m	30cm	10cm	0.1 km/h	0 km/h	10min
	Warning of leaving behind of portable equipment and portable commodity	Person and real-time, relative, positional confirmation of portable equipment	3m	10cm	3cm	3 km/h	0 km/h	1s

Long Middle Low