

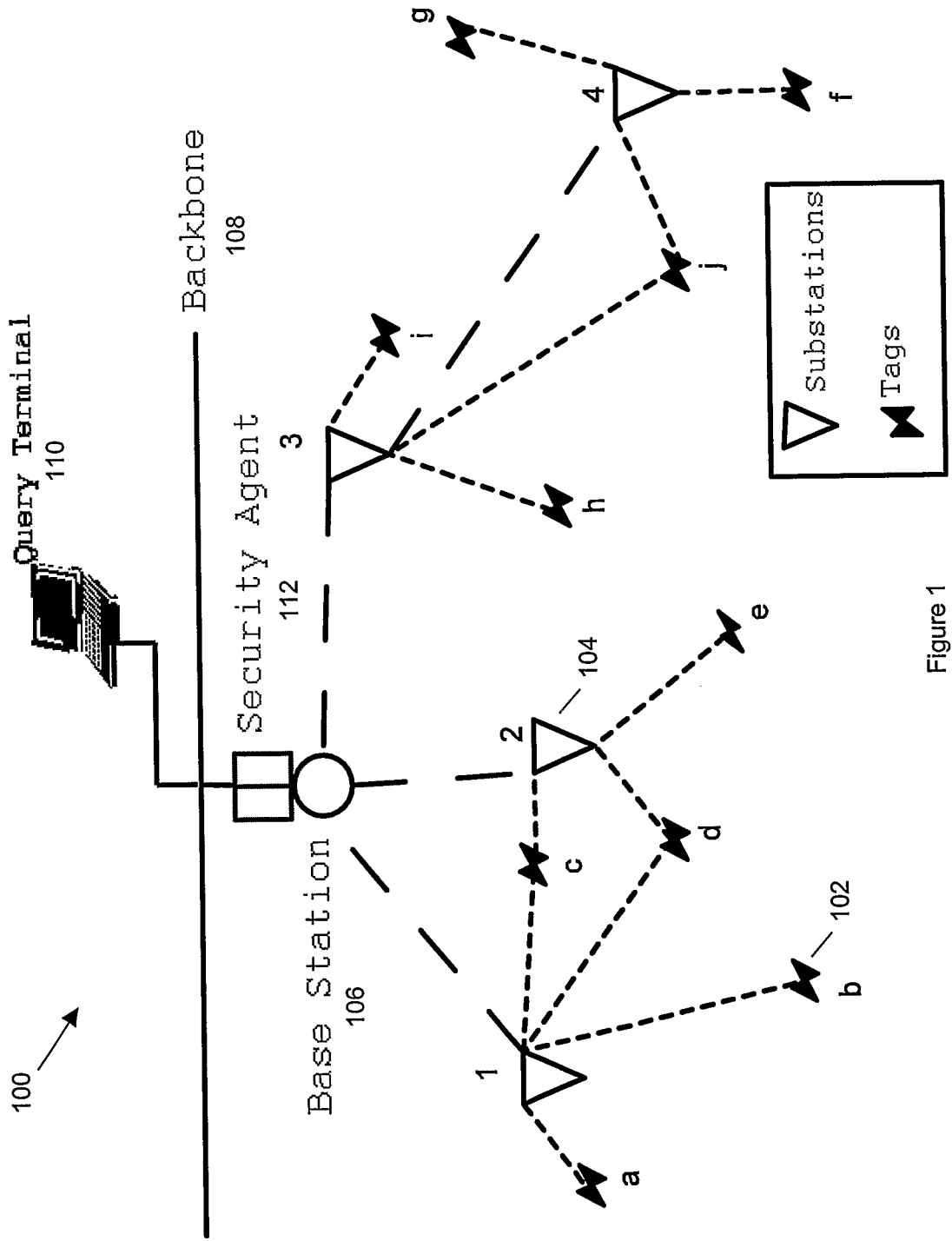


Figure 1

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MAX: Finding A Place

Settings Location Choices

Book, Harry Potter, Rowling, Secrets

Search

Searched Home, Jane's for Book, Harry Potter, Rowling, Secrets

Book: Joanne Kathleen Rowling, Harry Potter and the Chamber of Secrets
located at **peter's bedroom** -> **bed** -> **shelf**

Book: J.K. Rowling, Harry Potter and the Half-Blood Prince
located at **peter's bedroom** -> **wooden bookshelf** -> **2nd shelf**

Book: JK Rowling, Harry Potter and the Philosopher's Stone
located at **peter's bedroom** -> **wooden bookshelf** -> **2nd shelf**

Video: Harry Potter and the Philosopher's Stone, Warner Bros
located at **hall** -> **tv shelf** -> **cd rack**

Book: JK Rowling, Harry Potter and the Philosopher's Stone
located at **jane's bedroom** -> **study table**

Figure 2

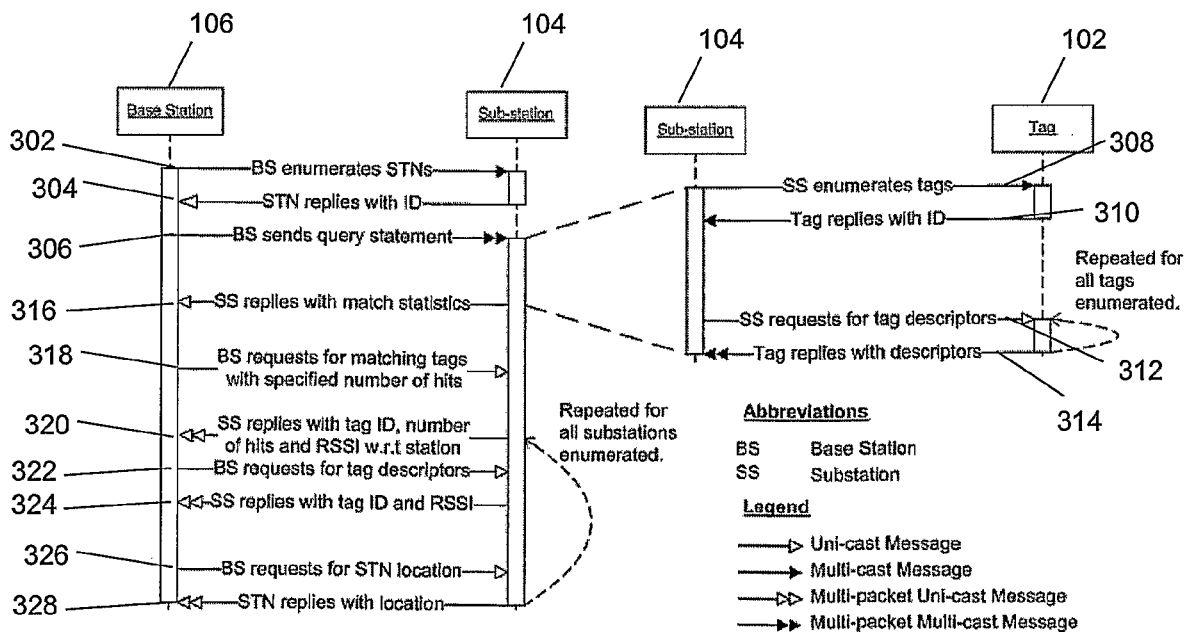


Figure 3

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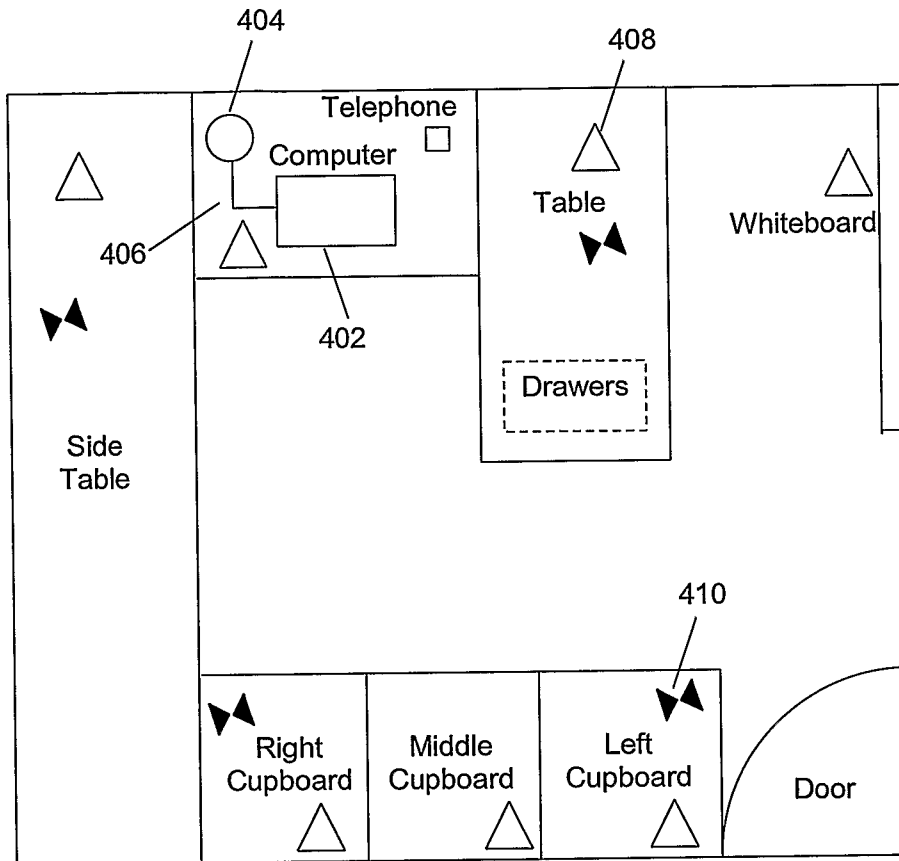
400

Figure 4

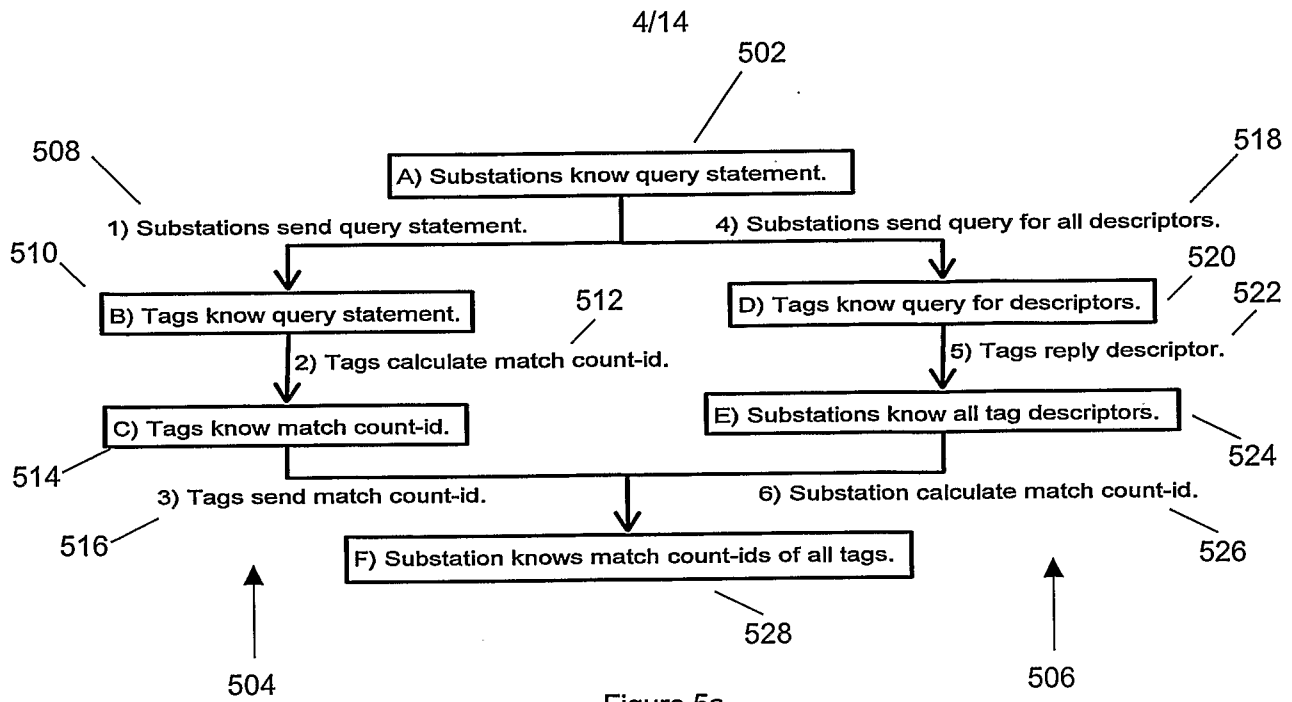


Figure 5a

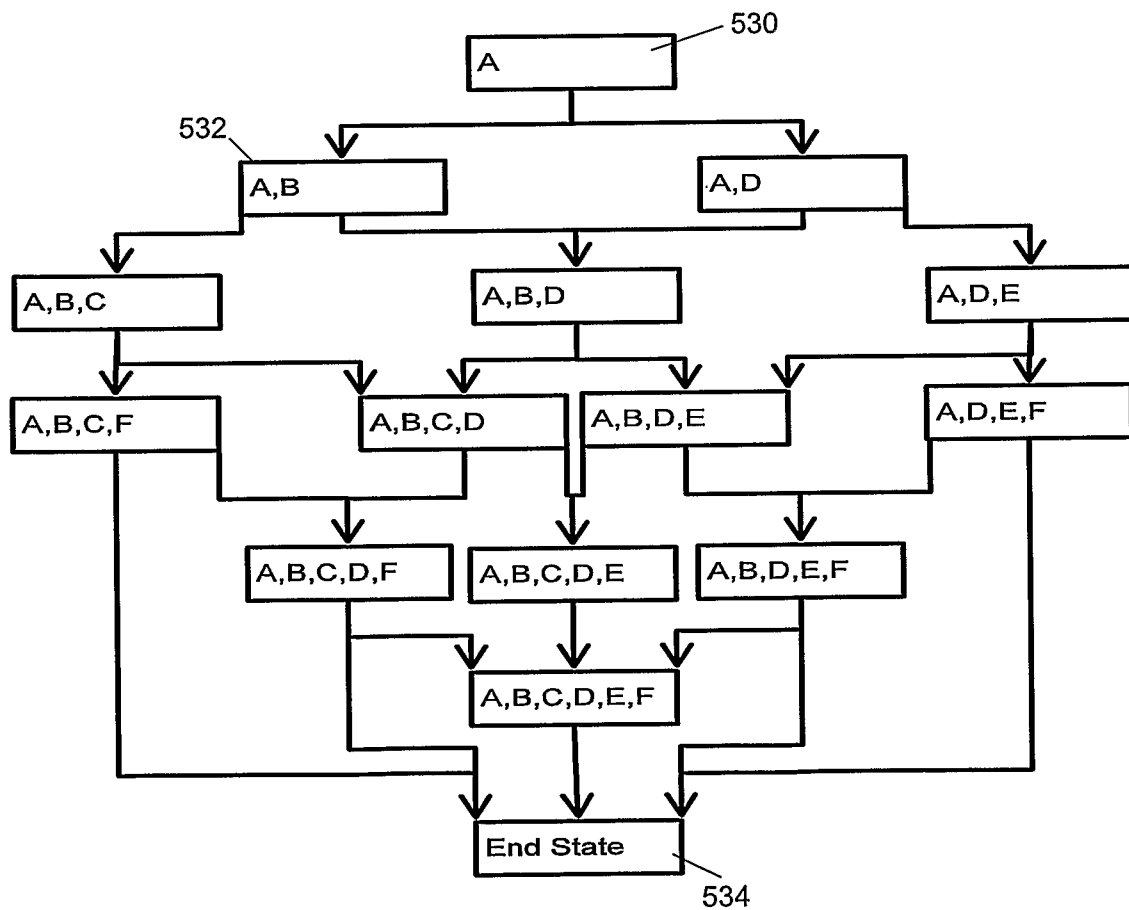


Figure 5b

Table I Hardware Device Parameters

Description	Symbol	Value
General Values		
Length of Match Value	L_M	1 byte
Length of RSSI Values	L_R	1 byte
Length of Query	L_Q	4 words
Maximum Length of Descriptor	L_D	8 words
Length of Each Word	L_W	16 bytes ^a
Base-station to Sub-stations Communication (MICA2DOT Mote)^g		
Power Required to Transmit	P_S^T	8.7 mW ^c
Data Rate	R_S	38.4 kbps
Substations (MICA2 Mote)^d		
Processing Speed	S_S	4 MHz
Power Required	P_S^A	46.5 mW
Substation-Tags Communication (SkyeRead M1-Mini^e)		
Power Required ^f	P_T	82.5 mW
Data Rate ^g	R_T	26 kbps
Tags (RFID)^h		
Processing Speed ⁱ	S_T	20 kHz

^aThe average length of an English word, considering all words, is between 4 and 5. However, the average length of word in use may not be so. Thus, a convenient value is chosen for analysis before an more accurate value can be determined from further research.

^bInformation can be found in [4] and [5].

^cThis represents the additional power required for the sub-station to transmit. The power required to keep it awake is also required.

^dInformation are extracted from [4].

^eThe reader has a read range of 7 to 15 cm depending on the antenna used. The values are available in [6]. The SkyeRead M1-Mini is assumed to be switched off when not in use, thus drawing 60 μA .

^fPower is provided by RFID reader.

^gData rate is based on ISO15693.

^hProcessing power would be the same as the communication power requirement at 82.5 mW, since the tags are passive.

ⁱThe processing of the RFID tag are accomplished by hardware implementations and thus support true parallel processing. However, the speed is highly restricted by the power available. Thus, a equivalent speed of 18.7 kHz is estimated from the required processing for comparing a unique identifier, as specified in ISO15693. Therefore, the convenient value of 20 kHz is used.

Figure 6a

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Table II Simulation Parameters

Description	Symbol	Value
Number of Substations		
Exact Number of Substations ^a	N_S	50
Number of Tags		
Sum of Tags under each Substation ^b	$\sum_i N_T^i$	2250
Maximum Number of Tags under a Substation	$\max_i N_T^i$	45
Number of Selected Tags		
Total Number of Selected Tags ^c	$N_{T(S)} = \sum_i N_{T(S)}^i$	40
Maximum Number of Selected Tags under a Substation ^d	$\max_i N_{T(S)}^i$	10
Scaling Factor for Different Decision ^e		
Decision by Substations		1.5
Decision by Base-Station, where a threshold match count is used for querying the descriptors.		1.3
Decision by Base-Station based on approximated statistics, where specific identities are used for querying the descriptors.		1.15
Decision by Base-Station based on accurate statistics and specific identities are used for querying the descriptors.		1

^aWe consider a 5 m by 5 m room densely deployed with sub-stations. Thus, the total number of furniture and immobile objects is estimated to be around 50.

^bAn average of 30 tags is expected for each sub-station, giving a total of 1500 tags in reality. However, due to overlapping coverage of the sub-stations, the number is multiplied by 1.5. This degree of overlap is low, since we are considering Skye's RFID reader with a maximum range of 15 cm.

^cWe assume that a user would require a total of 40 results only. It is based on the intuition that searches are seldom useful beyond a small portion of the returned results.

^dWe assume an asymmetric distribution of desired objects in the room. This is assumed because it is common to cluster similar objects together.

^eWe note that the values of $\sum_i N_{T(S)}^i$ and $\max_i N_{T(S)}^i$ would be different for different types of decision made. For example in Figure , the tag d will be returned twice by sub-stations 1 and 2 if a local decision is made. This is because this overlap information is not available to all the sub-stations. Thus, we scale these values for different decisions made.

Figure 6b

Table III Energy-Latency Values of Optimal Protocols

Scenarios ^a				Energy /J	Latency /s ^b	
1	Centralized	Dumb Tags	Heuristic	12.346	4.672	
2	Centralized	Smart Tags	Heuristic	0.663	3.355	
3	Distributed	Dumb Tags	Heuristic	12.344	4.641	702
4	Distributed	Smart Tags	Heuristic	0.637	3.323	
5	Centralized	Dumb Tags	Maximally relevant	12.511	7.762	
6	Centralized	Smart Tags	Maximally relevant	0.767	6.378	
<i>High Overlap System</i>						
7	Centralized	Dumb Tags	Heuristic	41.097	15.162	
8	Centralized	Smart Tags	Heuristic	1.519	7.420	
9	Distributed	Dumb Tags	Heuristic	40.810	12.674	704
10	Distributed	Smart Tags	Heuristic	0.860	3.764	
<i>Low Number of Tags</i>						
11	Centralized	Dumb Tags	Heuristic	3.678	3.413	
12	Centralized	Smart Tags	Heuristic	0.538	3.369	706
13	Distributed	Dumb Tags	Heuristic	3.672	3.283	
14	Distributed	Smart Tags	Heuristic	0.538	3.283	
<i>High Number of Tags</i>						
15	Centralized	Dumb Tags	Heuristic	17.782	5.729	
16	Centralized	Smart Tags	Heuristic	0.757	3.658	708
17	Distributed	Dumb Tags	Heuristic	17.768	5.653	
18	Distributed	Smart Tags	Heuristic	0.676	3.437	

^aSmart refers to the capability of the tags.

^bIf the optimal energy protocol is not equal to the optimal latency protocol, the energy of the optimal energy protocol and the latency of the optimal latency protocols are given.

Figure 7

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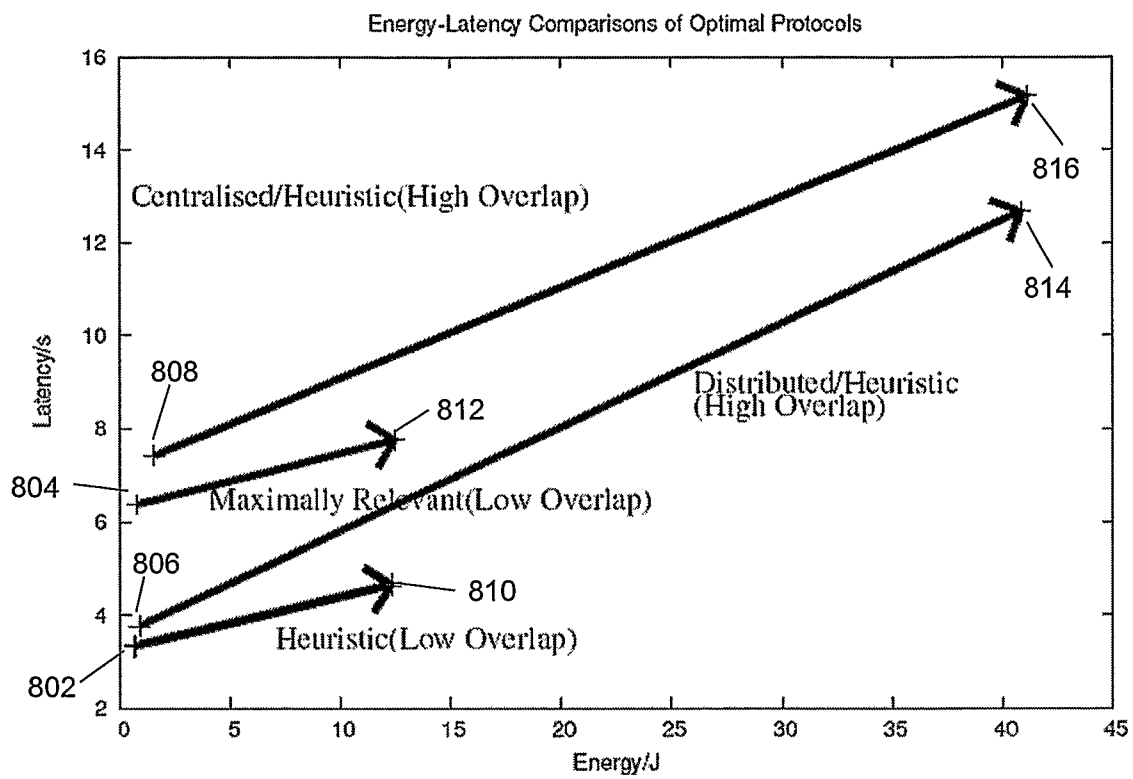


Figure 8a

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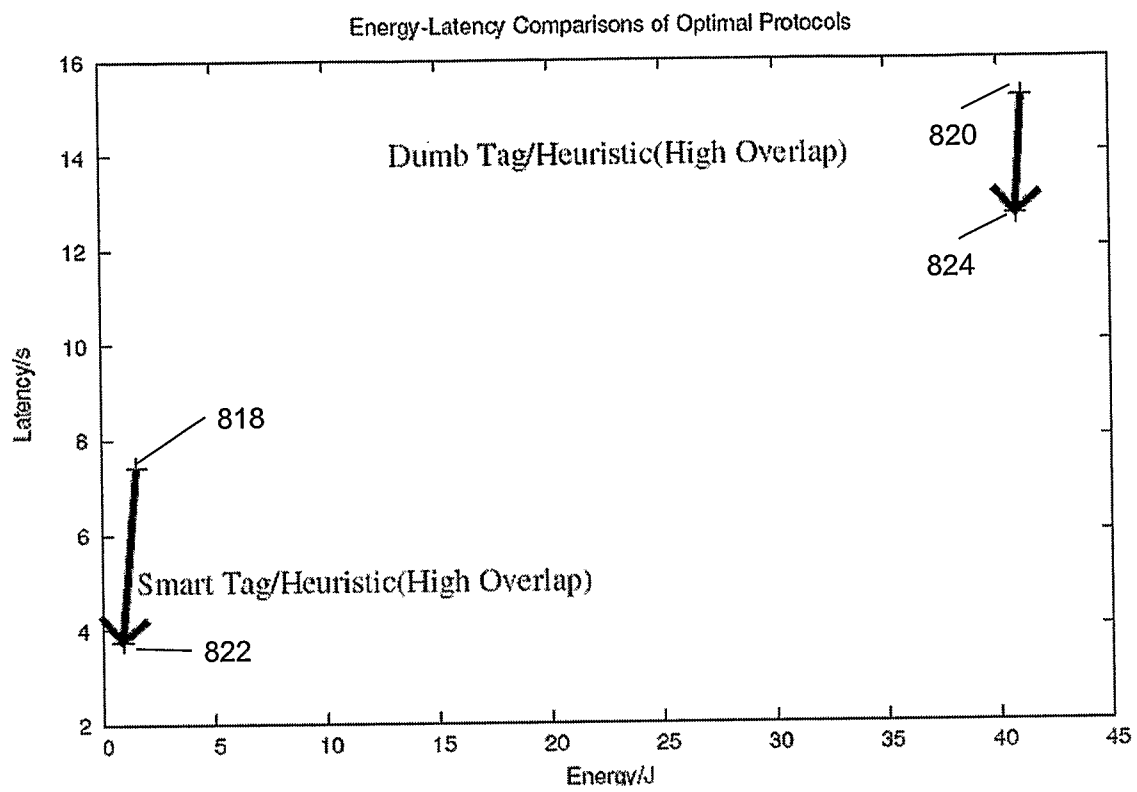


Figure 8b

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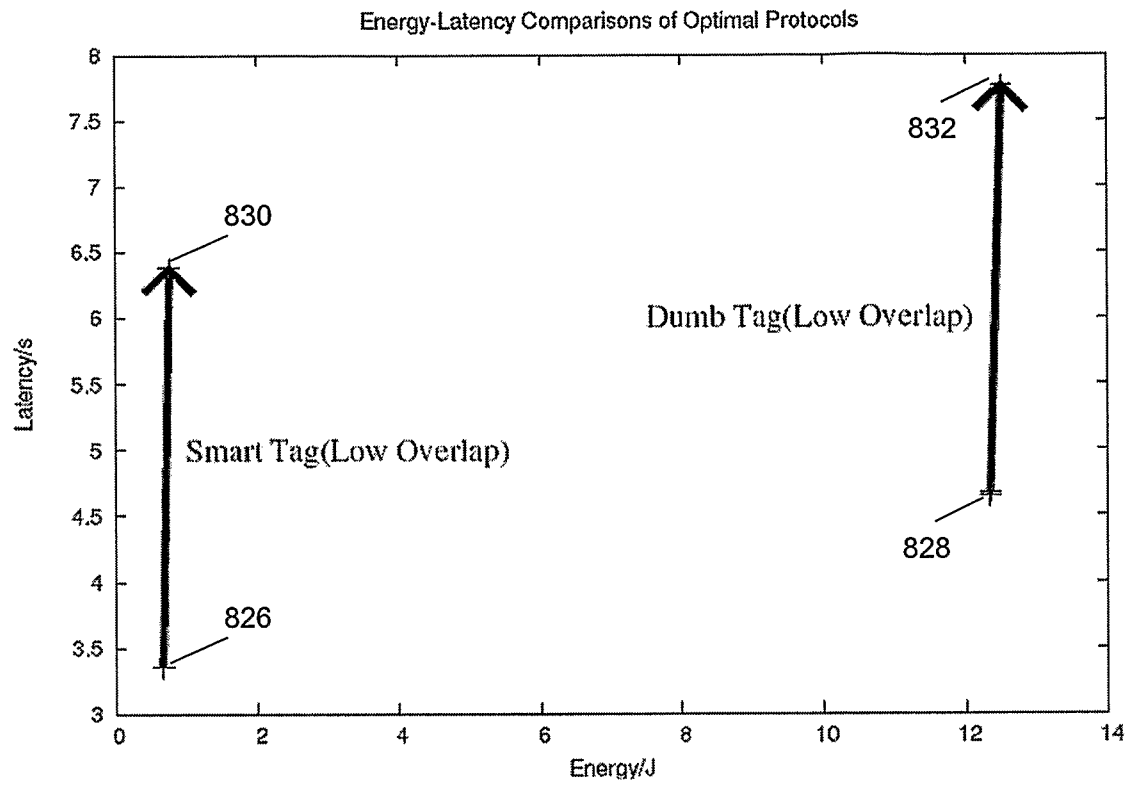


Figure 8c

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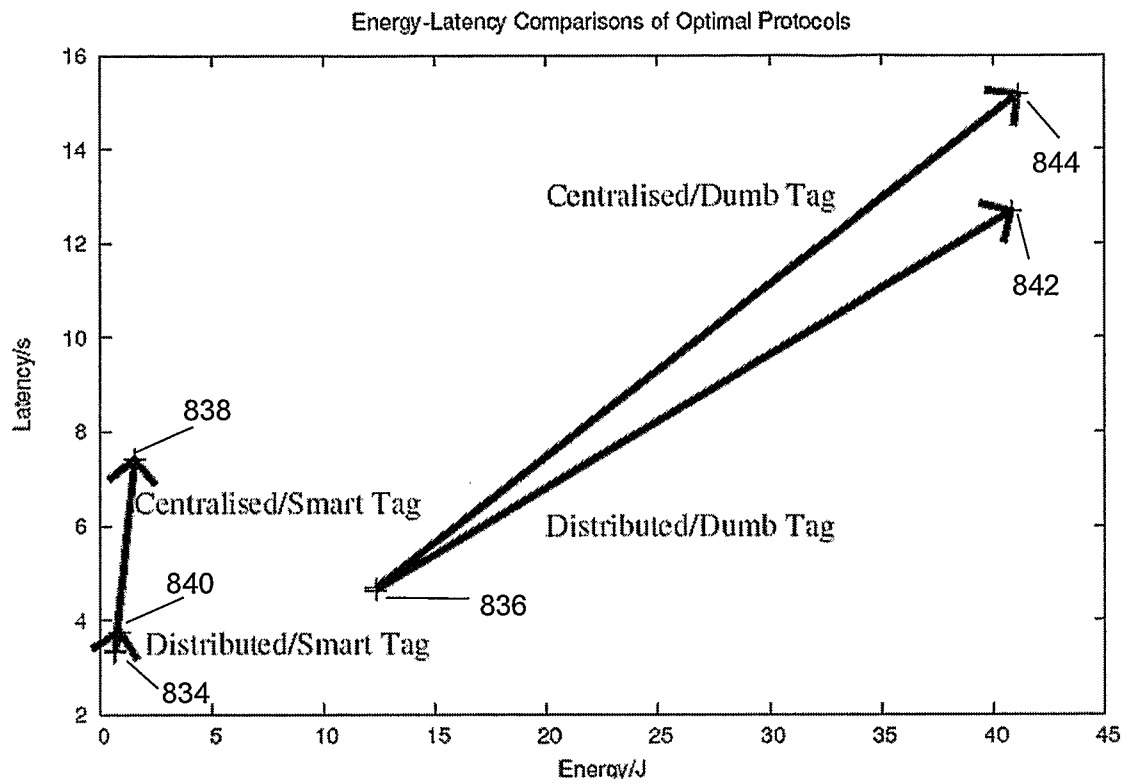


Figure 8d

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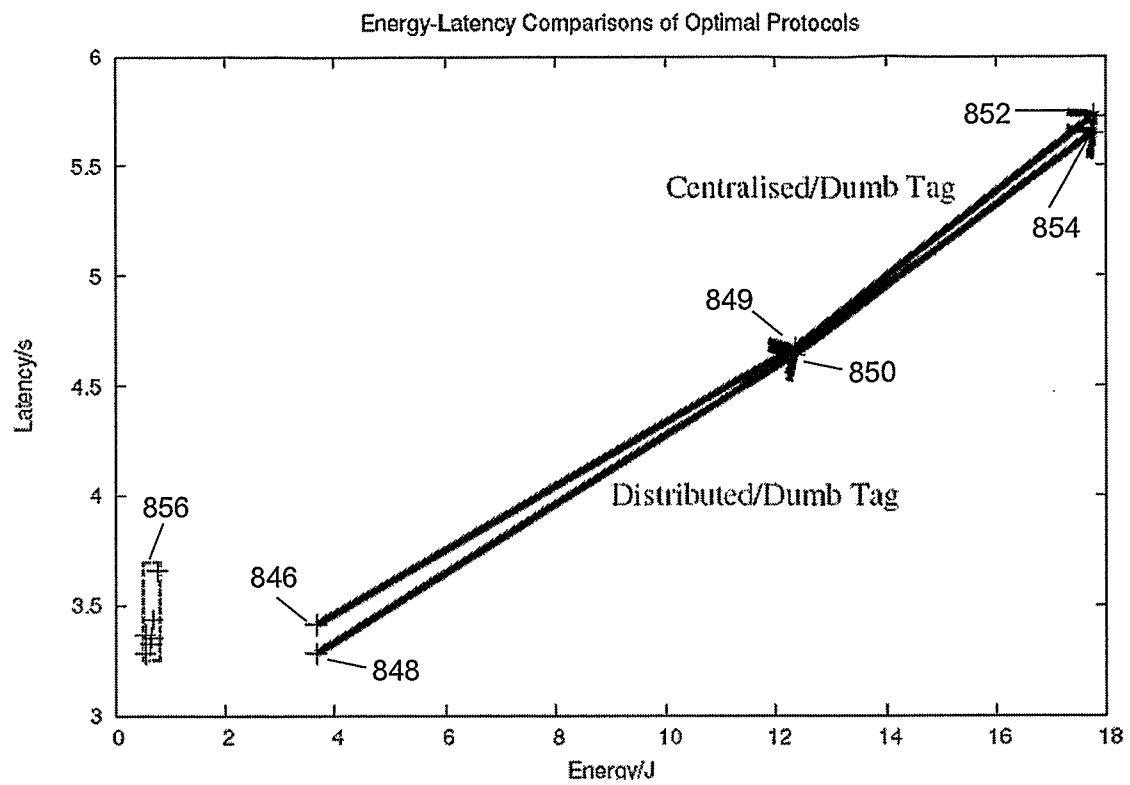


Figure 8e

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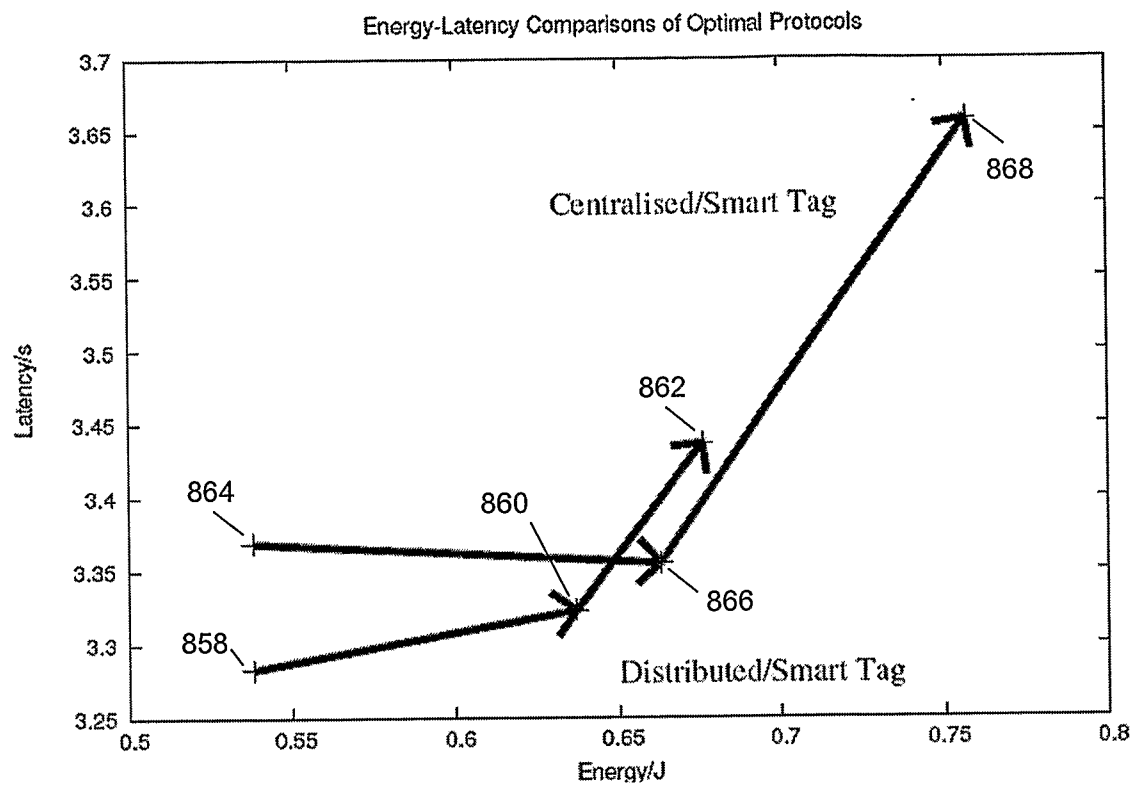


Figure 8f

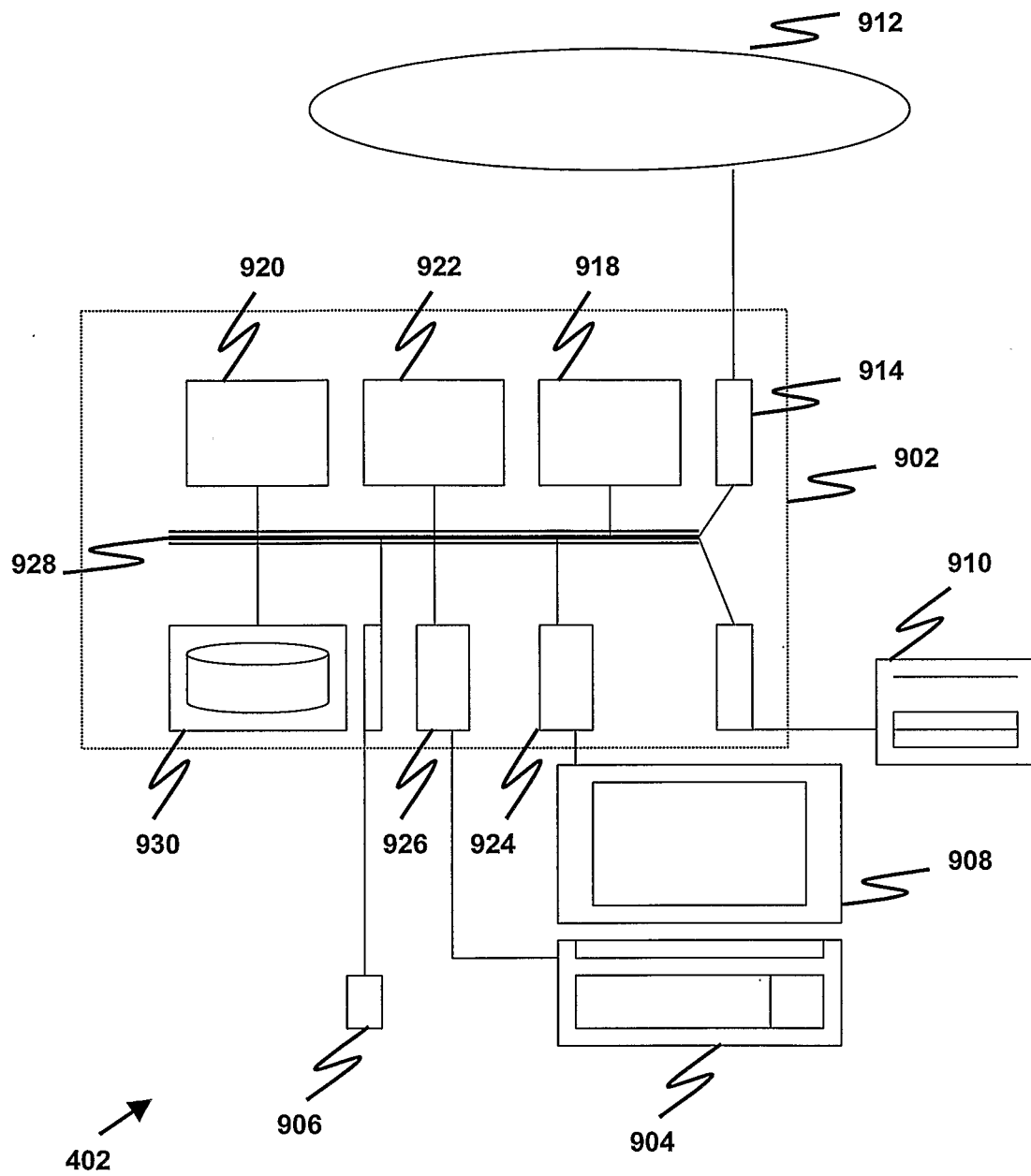


Figure 9