MaD-WiSe: Management of Data in Wireless Sensor Networks

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Peculiarities of WSN applications

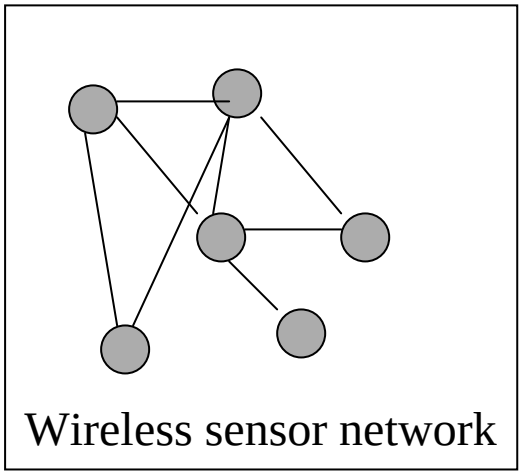
- Several applications on WSN produce and process huge amount of data
  - Data are continuously produced (data streams)
  - Data produced by different sensors might need to be compared/matched
  - Behaviour of sensors might need to be adjusted/refined over time
  - Environmental situation can change so new strategies might need to be used
  - Use of gathered data is not always known a priori

Declarative Queries

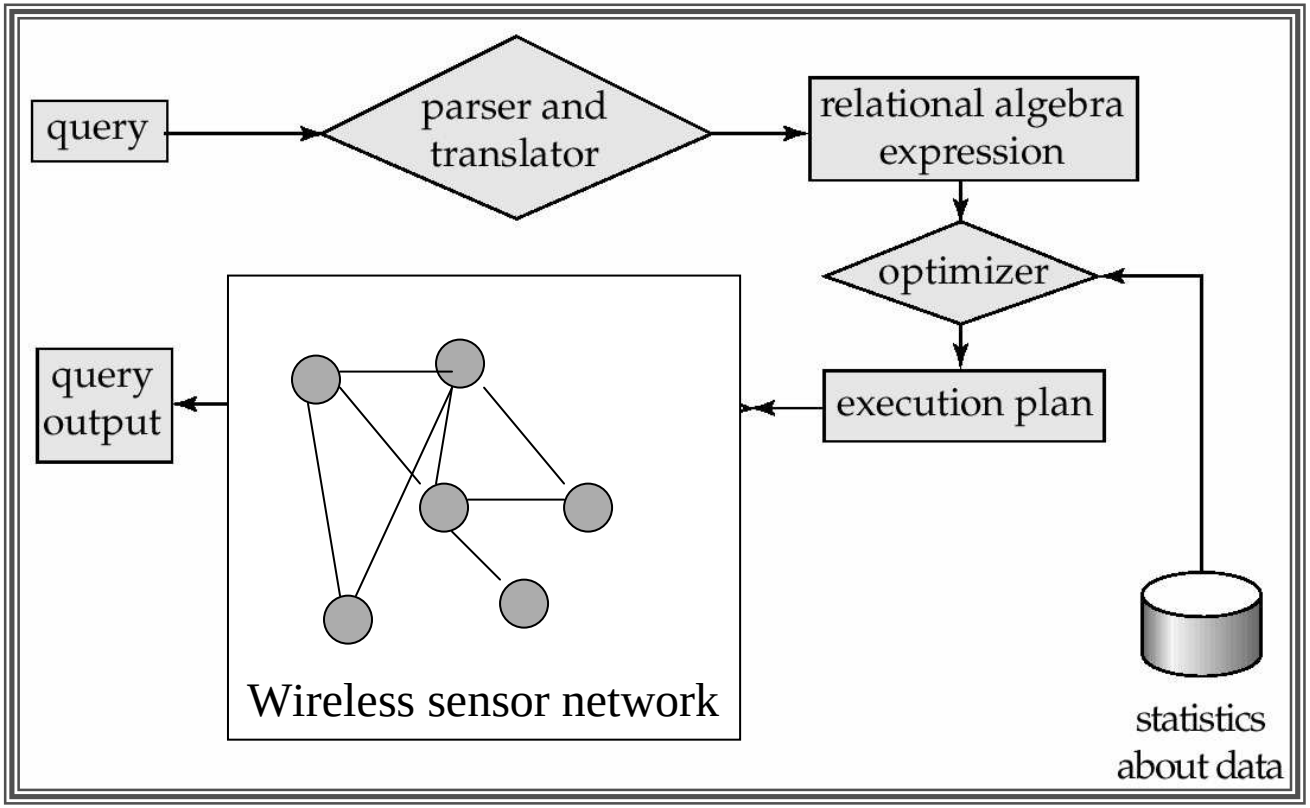
- Programming Apps is Hard
  - Limited power budget
  - Lossy, low bandwidth communication
  - Require long-lived, zero admin deployments
  - Distributed Algorithms
  - Limited tools, debugging interfaces
- Queries abstract away much of the complexity
  - Burden on the database developers
  - Users get:
    - Safe, optimizable programs
    - Freedom to think about apps instead of details

Data management: trivial approach

All sensed data go to a PC to be stored and processed



Wireless Sensor Network as a distributed database



MaDWiSe approach

- Existing approaches do not distinguish among data acquisition, data transfer, data processing phases
- Our approach -> layered architecture:
  - Network layer
  - Stream system
  - Stream query processing
- All nodes ow the WSN have these layers

Network layer (1)

- Localization and Routing:
  - Virtual Coordinate assignment protocol (VCap):
    - Large sensor networks, not equipped with localization devices such as GPS
    - Distributed protocol which defines a coordinate systems unrelated to the sensor location
    - VCap selects three anchors in the network boundary and assigns to each node a triplet of coordinates which represents the hop distance of the node from the three anchor nodes
    - The coordinate system can efficiently support greedy geographic routing

Network layer (2)

- Energy-efficient, application-driven communication:
  - Many applications use channels at fixed data rate
    - E.g.: directed-diffusion paradigm or data-base oriented applications
  - Connection-oriented communication protocol
  - Estimation of the next packet arrival time and turn on/off the radio accordingly
    - Minimization of the packet losses due to radio off
    - Minimization of energy consumption
  - Sensors not involved in the communication channels turn off the radio

Stream system (1)

- Wireless sensor network mainly produce and process streams of data
- Tree types of data sources
  - Transducers -> *Sensor streams*
  - Local applications -> *Local streams*
  - Network -> *Remote streams*

- Stream system: the equivalent of the “file system” for WSN applications
  - open, close, read, write like operations on various type of streams
  - Streams are n -> 1 (n can write, 1 can read)
    - This limit is easily manageable

Stream system (2)

- Sensor Streams
  - A transducer writes, any local application can read
  - You can specify
    - the transducer
    - The acquisition rate
      - E.g. every *x* ms, or on demand
    - The lifetime
    - The buffer size

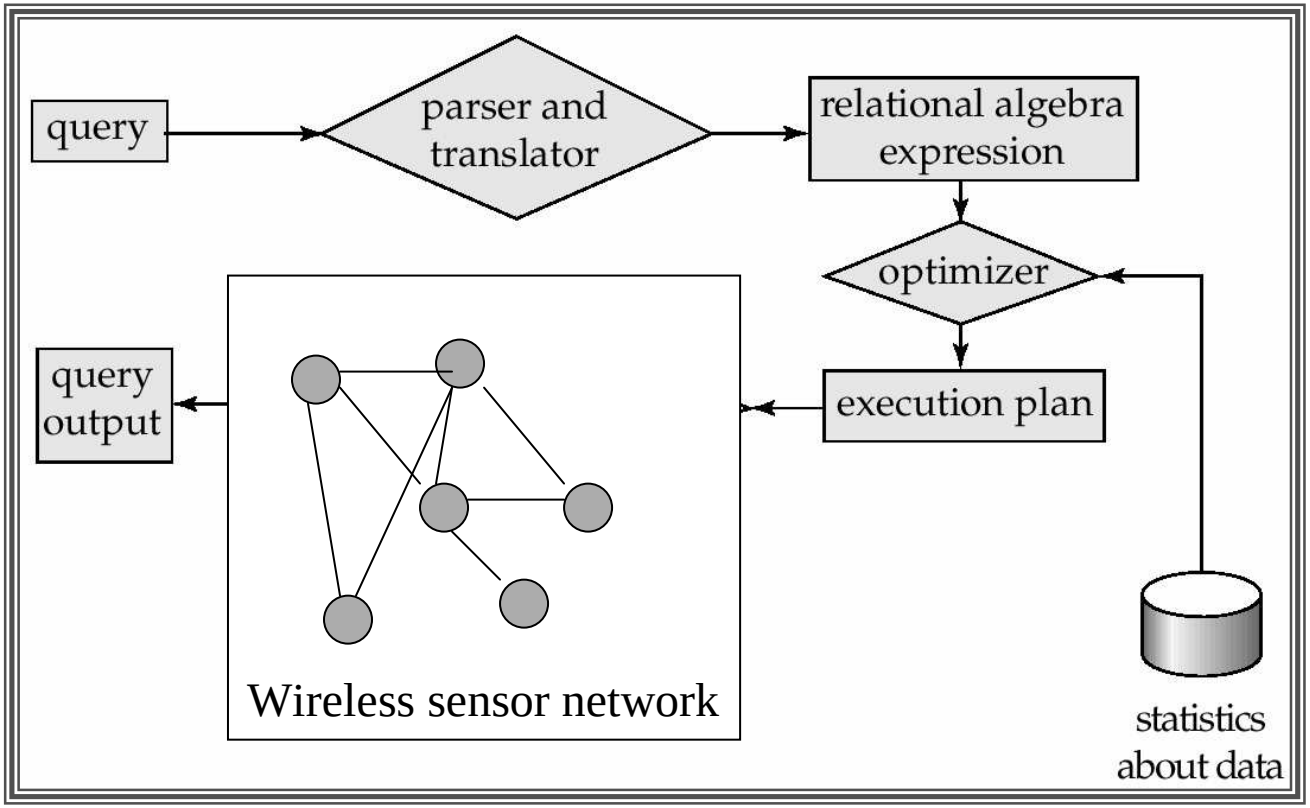
Stream system (3)

- Local streams
  - A local application writes
  - A local application read
  - You can specify
    - The data rate
    - The lifetime
    - The buffer size

Stream system (4)

- Remote streams
  - A possibly remote application writes
  - A possibly remote application reads
  - You can specify
    - A global name for the stream
    - The data rate (useful for energy efficient communication)
    - The lifetime
    - The buffer size
    - A reliability strategy

WSN as a database: Architecture



WSN as a database: Stream query processor

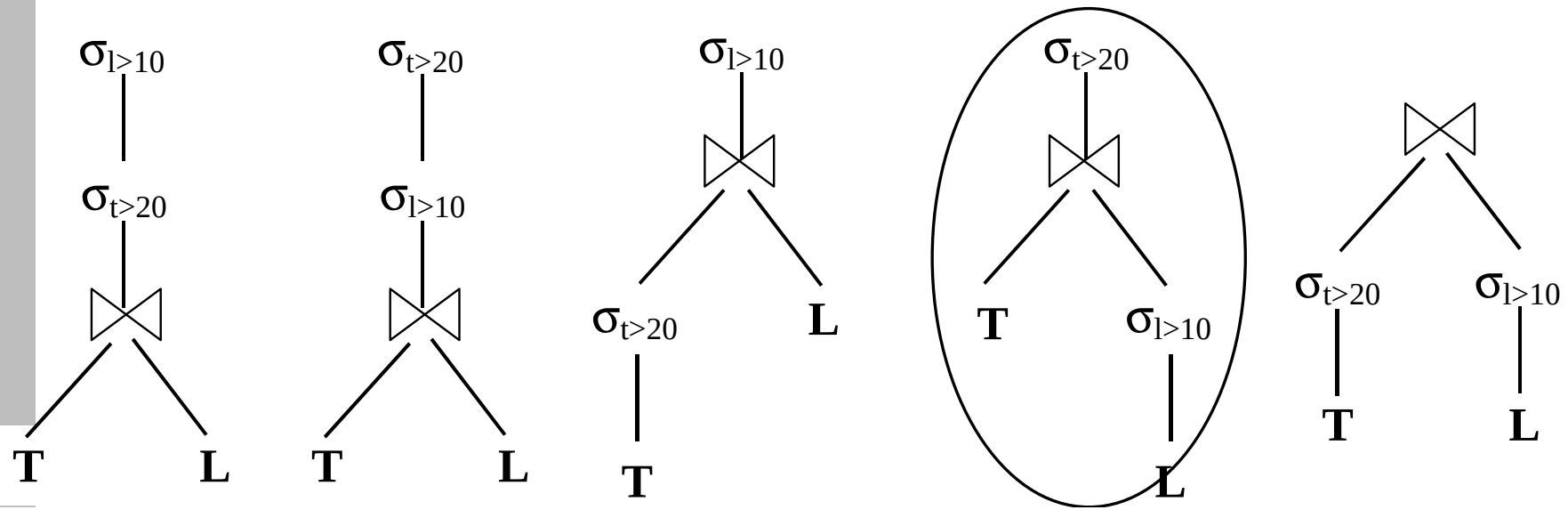
- In traditional databases queries access relations
- In our case queries access data streams
  - We use stream query processing techniques

WSN as a database: Simple query example

```
select t, l
from T,L
Where T.t_s=L.t_s
      t > 20 and
      l > 10
```

T		
t_s	t	…
0	10	..
1	15	…
…	…	…

L		
t_s	l	…
0	5	..
1	7	…
…	…	…

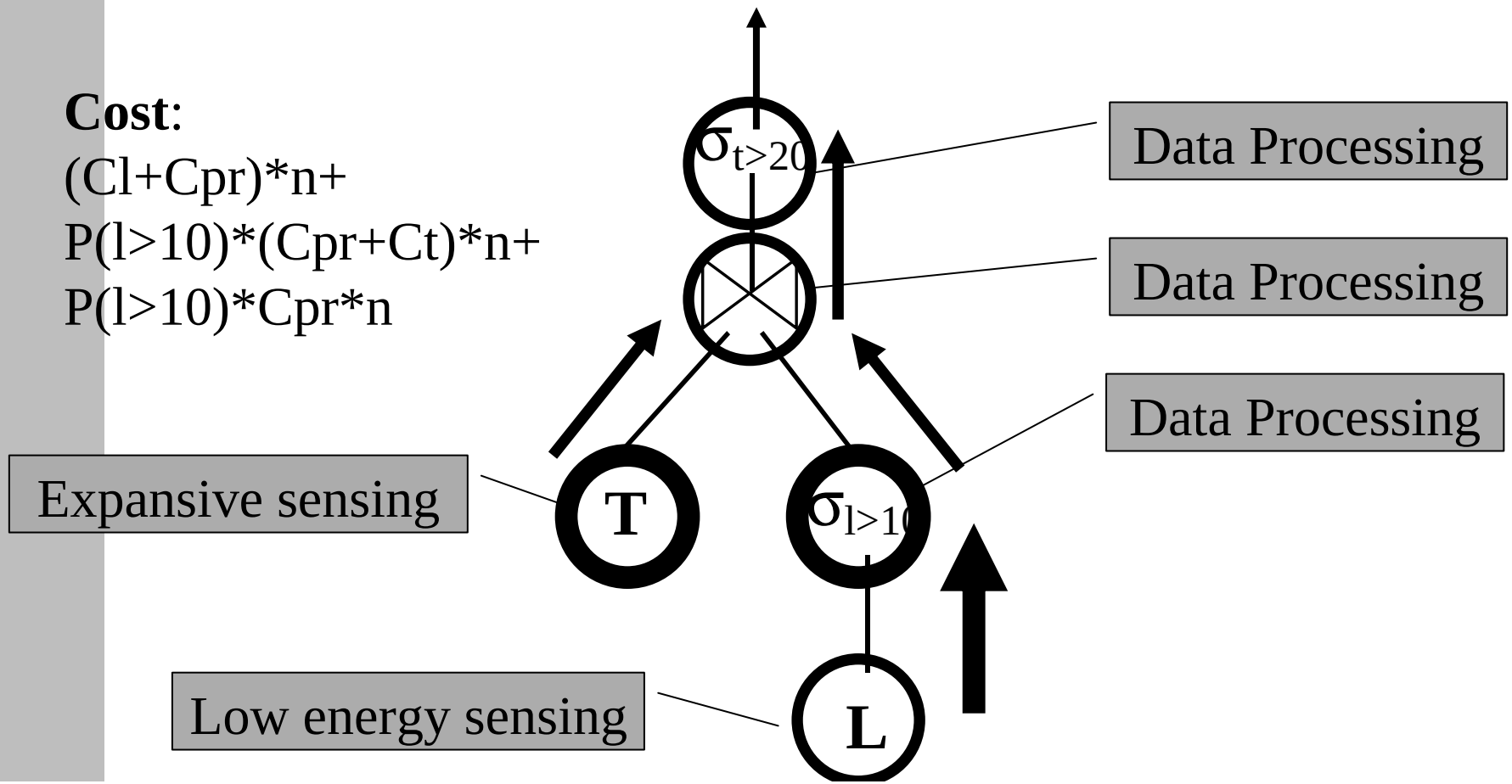


WSN as a database: Power aware query optimisation

- Cost of a query is estimated considering energy consumption
  - Processing data consumes energy
  - Sensing data consumes energy
    - Different sensors have different energy consumption
  - Transmitting data consumes energy
  - Receiving data consumes energy

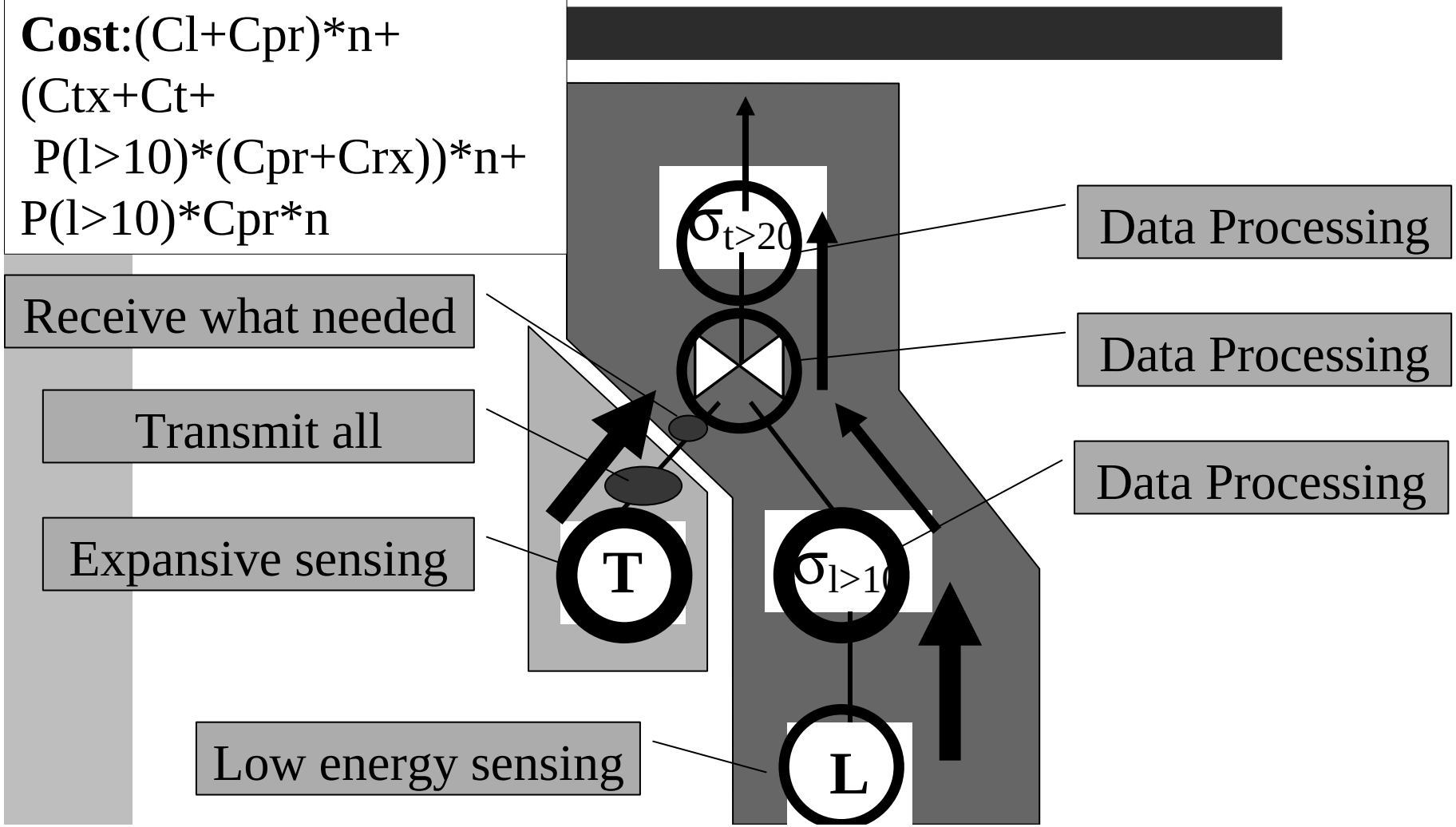
WSN as a database: Execution on a single node of a WSN

Cost:
(Cl+Cpr)*n+
P(l>10)*(Cpr+Ct)*n+
P(l>10)*Cpr*n



WSN as a database: Execution on two nodes of a WSN

Cost:(Cl+Cpr)*n+
(Ctx+Ct+
P(l>10)*(Cpr+Crx))*n+
P(l>10)*Cpr*n



MaDWiSe: Current Status

- Network layer
  - Design ready
  - Simple prototype ready (no smart energy management, no multi-hop)
  - Full functional prototype in progress
- Stream System
  - Design ready
  - Advanced prototype ready
  - Full functional prototype in progress
- Query execution
  - Query processor ready and incrementally updated
  - Graphical interface for query execution plan definition ready
  - SQL query parser and optimizer in progress