Managing energy and data quality in swarms

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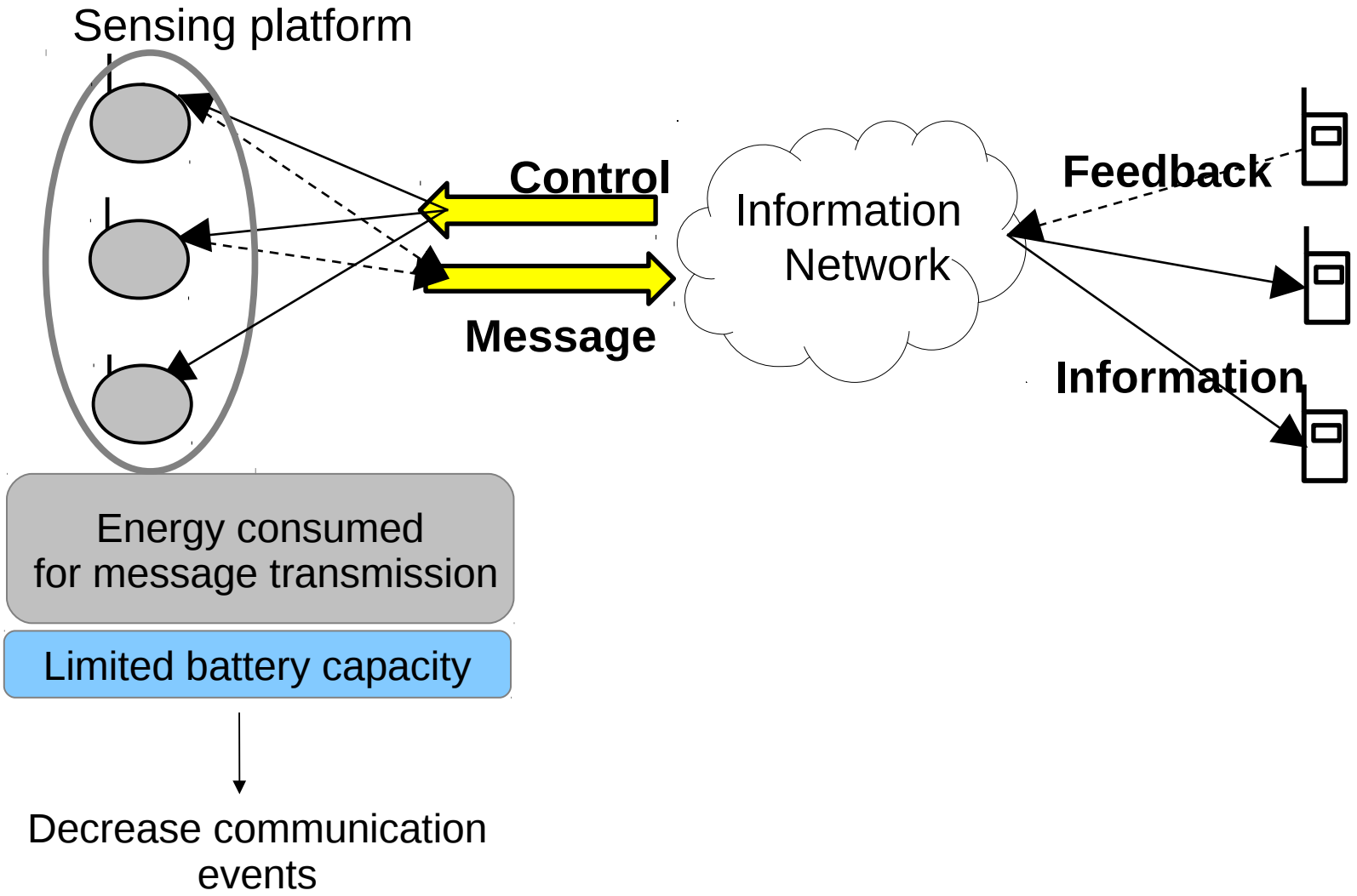
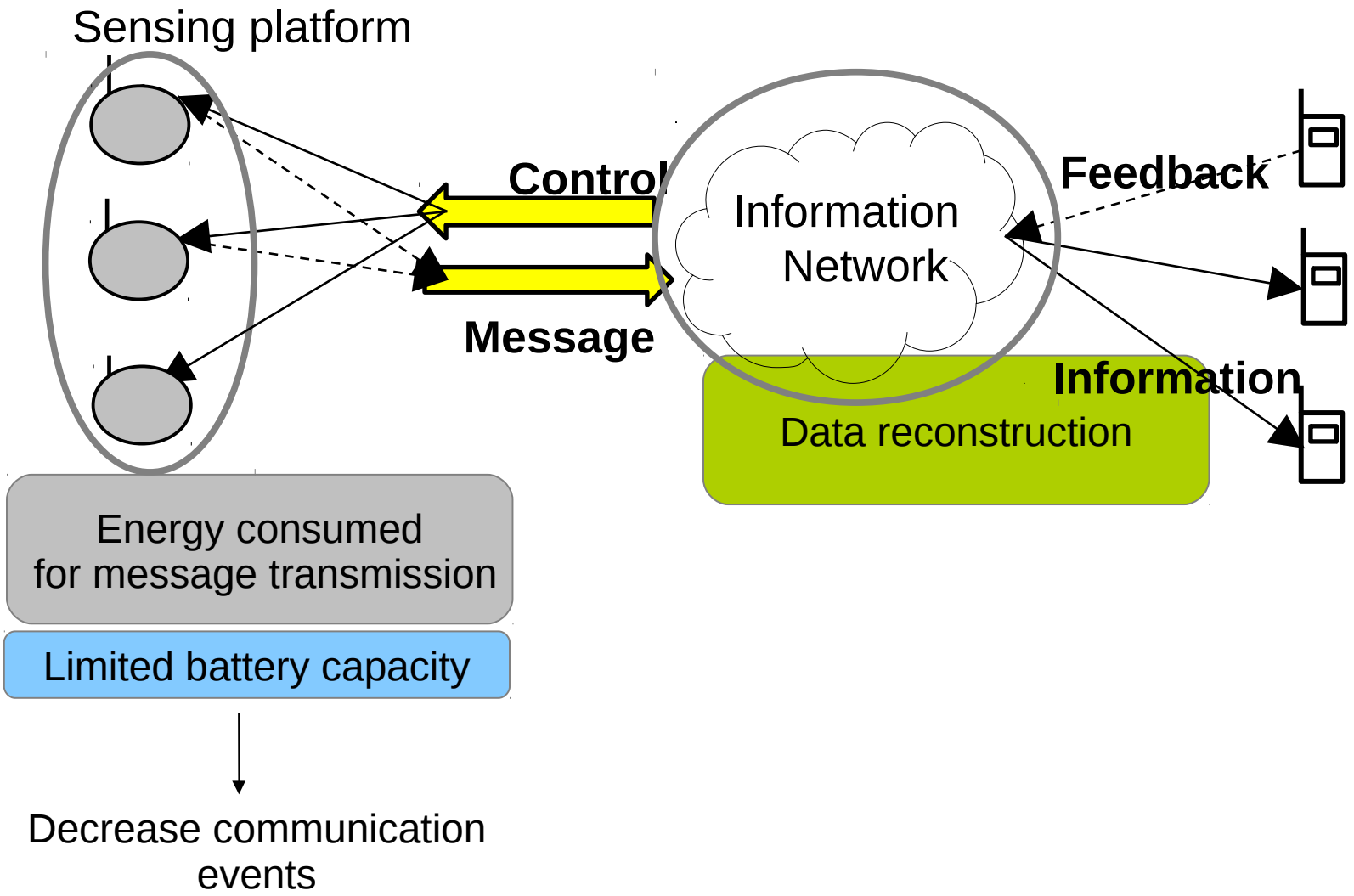
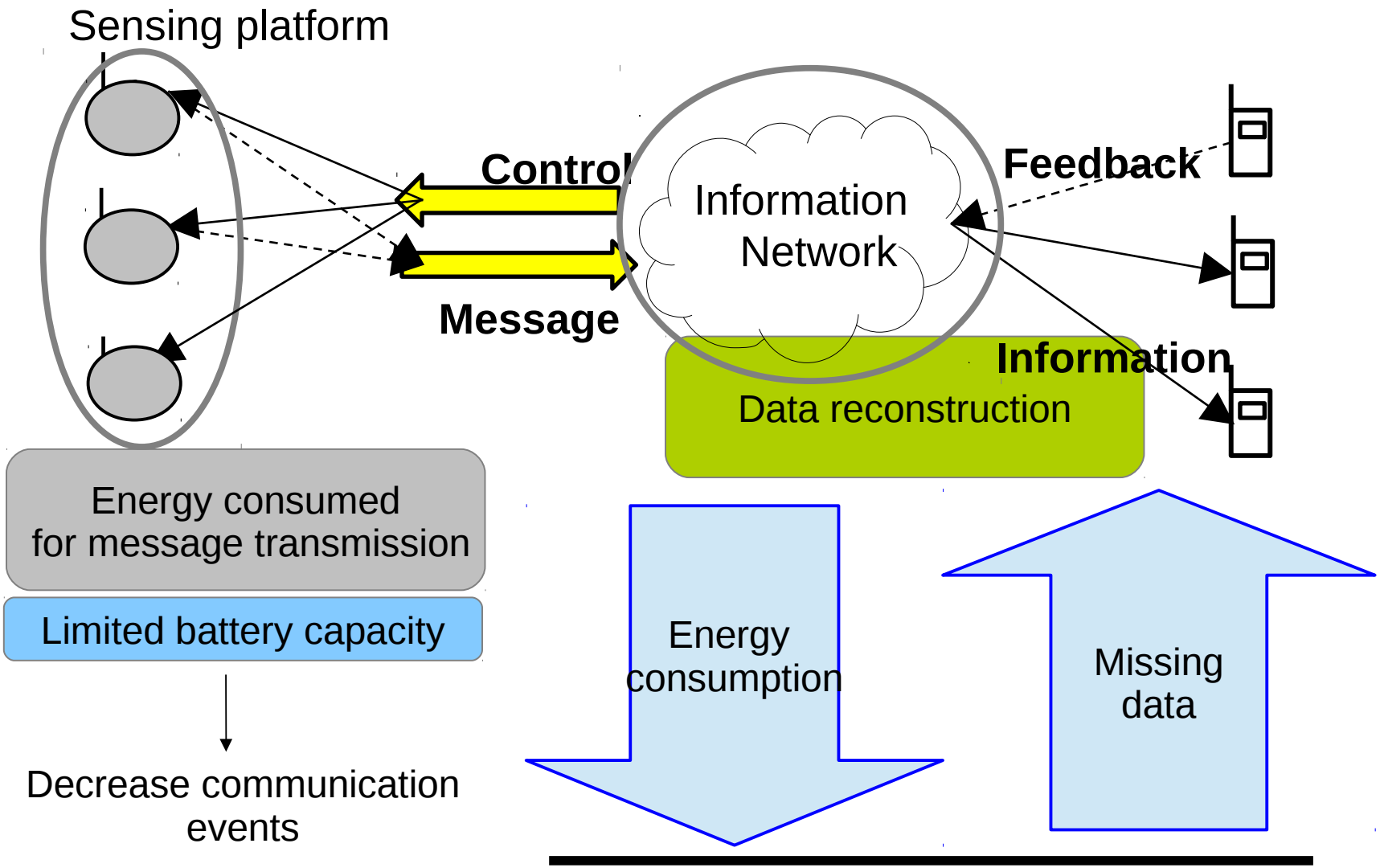
Data quality & managing energy



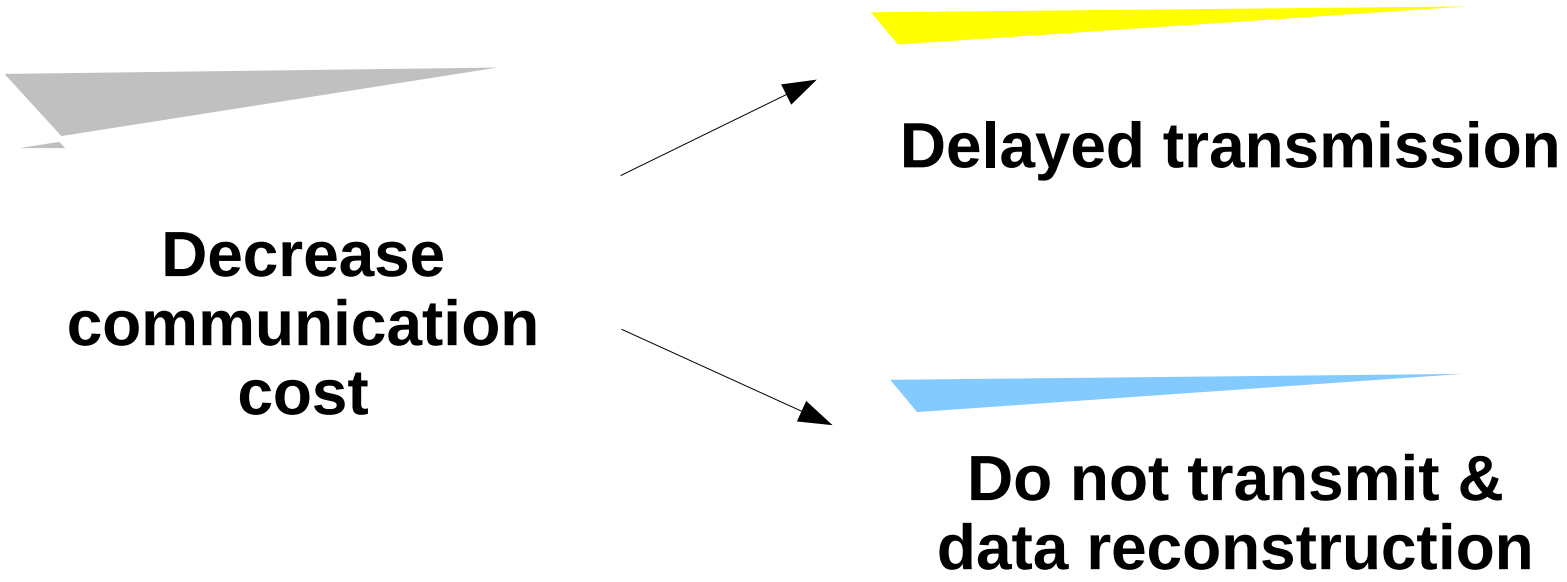
Data quality & managing energy



Data quality & managing energy



Strategies


Decrease communication cost
Delayed transmission
Do not transmit & data reconstruction

Challenges

- **Delayed transmission**

- Messages are forwarded via multi-hop routing paths

- Various sensors' messages have different delay sensitivity

- Delay sensitivity varies along routing paths

- Scalability : distributed approach

- **Data reconstruction**

- Training set for data reconstruction model is very sparse

- Inconsistent sparsity factor, k

- ***Different measurements have different k***

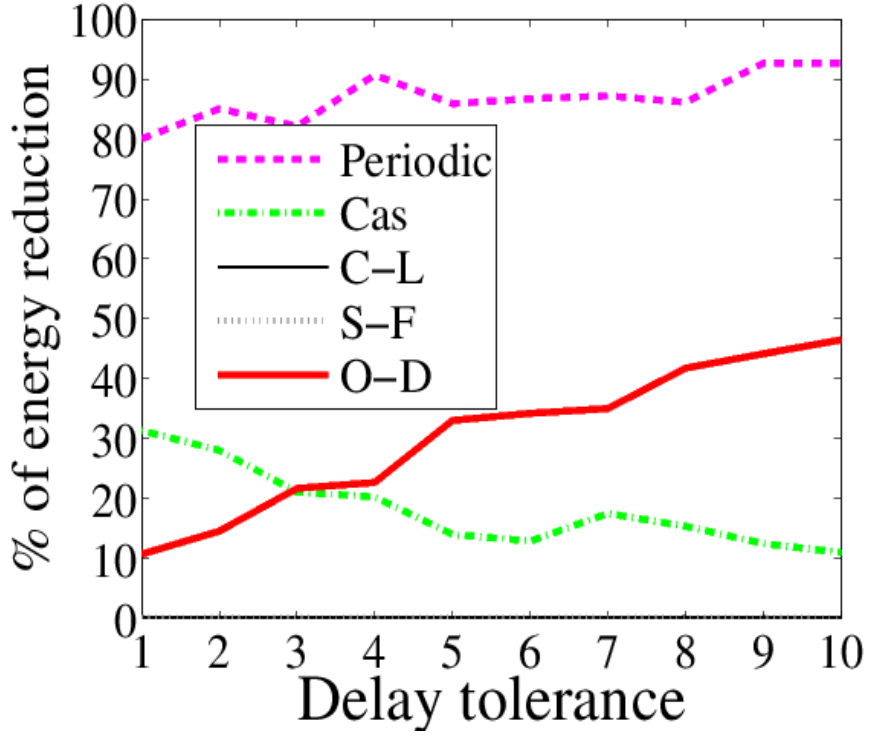
Optimal transmission manager

	Fixed	Periodic per Hop	Cascade timeout	Bursty	Delayed forwarding	Selective forward.	O-D
Fixed	O	O	O				
Distance to sink		O	O				O
Packet length				O			
Buffer length					O		O
Expiration time						O	O
Duty cycle					O		O

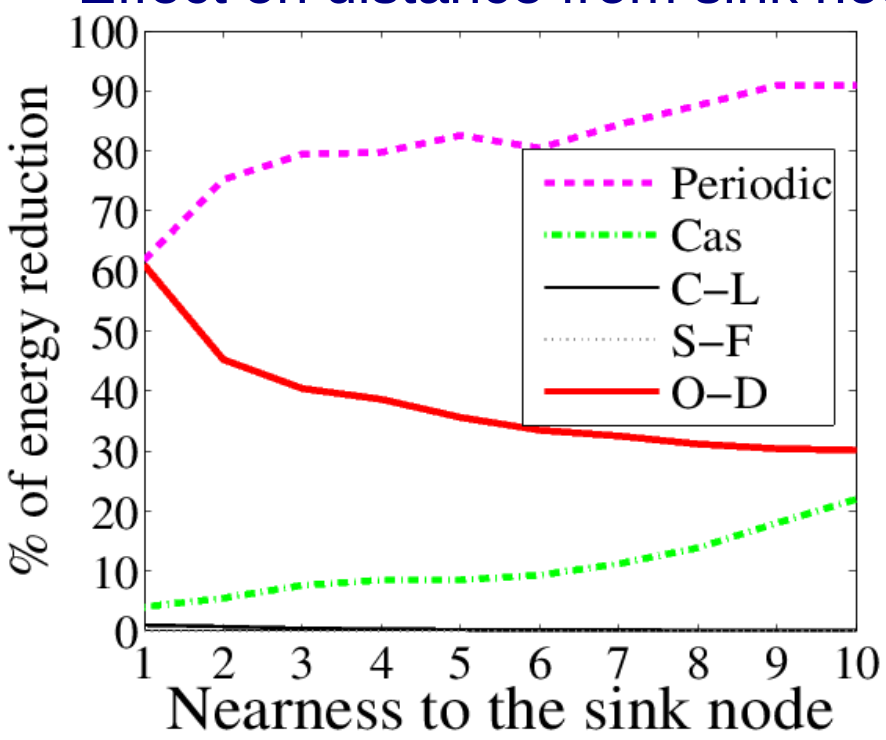
- **All generated messages are buffered at application buffer**
- **Two actions: stay vs. transmit**
  - **Decides action per message**

Optimal transmission manager

- Effect on delav tolerance



- Effect on distance from sink node



- Increase 26% to 48% energy efficiency with no messages timing out

Reconstruction missing parts

- **Compressive sensing use m x n matrix for reconstruction**
- **m is function of sparsity factor, *k***

Comparison of sparsity, *k*, of DCT domains for 24 samples with different time periods

Time slot	Solar (W/m^2)	Soil Temp. (C^o)	Air Temp. (C^o)	Wind speed (m/s)	Humidity (%)
0-0am	24	16	23	21	24
0-10am	10	5	10	10	10
10-0am	14	5	14	13	14

Matrix factorization

- **Find out hidden interaction among measurements**
  - time, sensor type, location
- **Not required sparsity factor, *k***

	MF	Pairwise	SVD++	Loc SVD++
Sensor type	O	O	O	O
Time	O	O	O	O
Location		O		O
Hidden factor			O	O

- **MF, Pairwise, SVD++ achieves up to 2approach times less reconstruction error given *k***
- ***Loc SVD++ outperform other approaches 1.2-4x in terms of reconstruction error***

Conclusions

- **Two approaches**
  - **Delayed transmission**
  - **Do not transmit & reconstructing missing parts**
- **Distributed transmission manager**
  - **Increase 26% - 48% energy efficiency without message expiration**
- **Reconstruction with matrix factorization**
  - **Extract hidden relationships among types of sensors, location, and measurement time**
  - **1.2 – 1.7 times less reconstruction error in compared to state of art methods**
- **What is next?**
  - **Interaction among different types of sensors**