LUND UNIVERSITY

SWEDISH FOUNDATION for STRATEGIC RESEARCH

An Energy Optimized Duty-cycled Wake-up Scheme for Wireless Sensor Networks

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for the Ultra-Portable Devices project

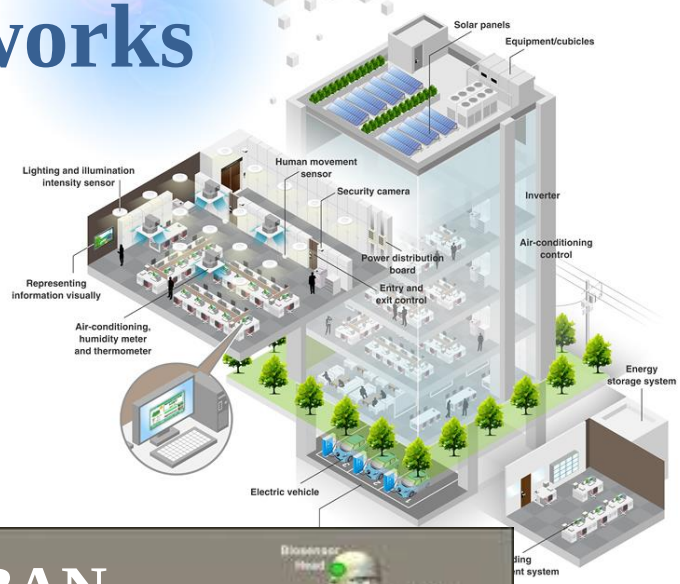
OUTLINE

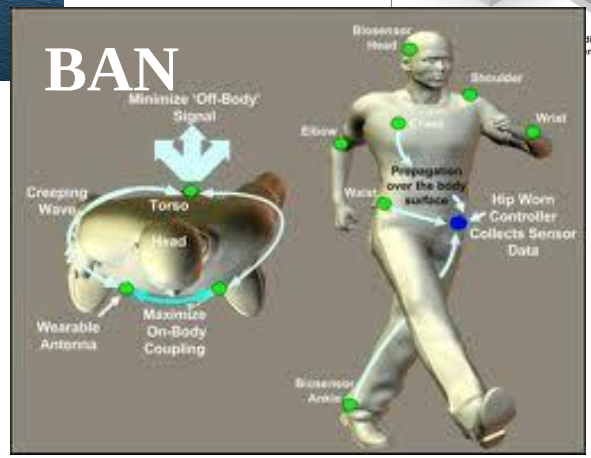
- INTRODUCTION
- TRANCEIVER STRUCTURE
- OPTIMIZATION
- FABRICATED DESIGN
- CONCLUSION

INTRODUCTION

Smart wireless sensor networks

Smart building

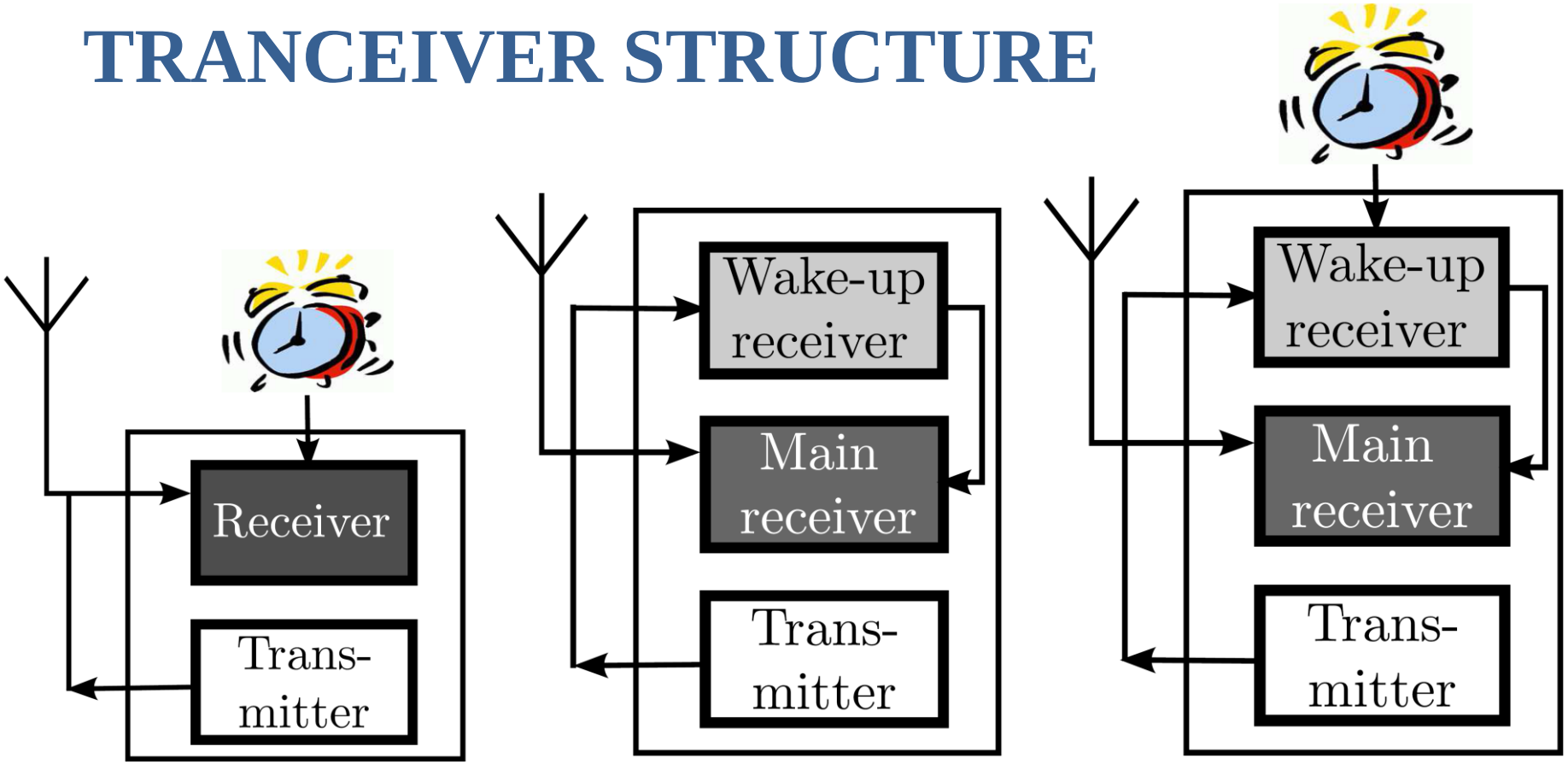




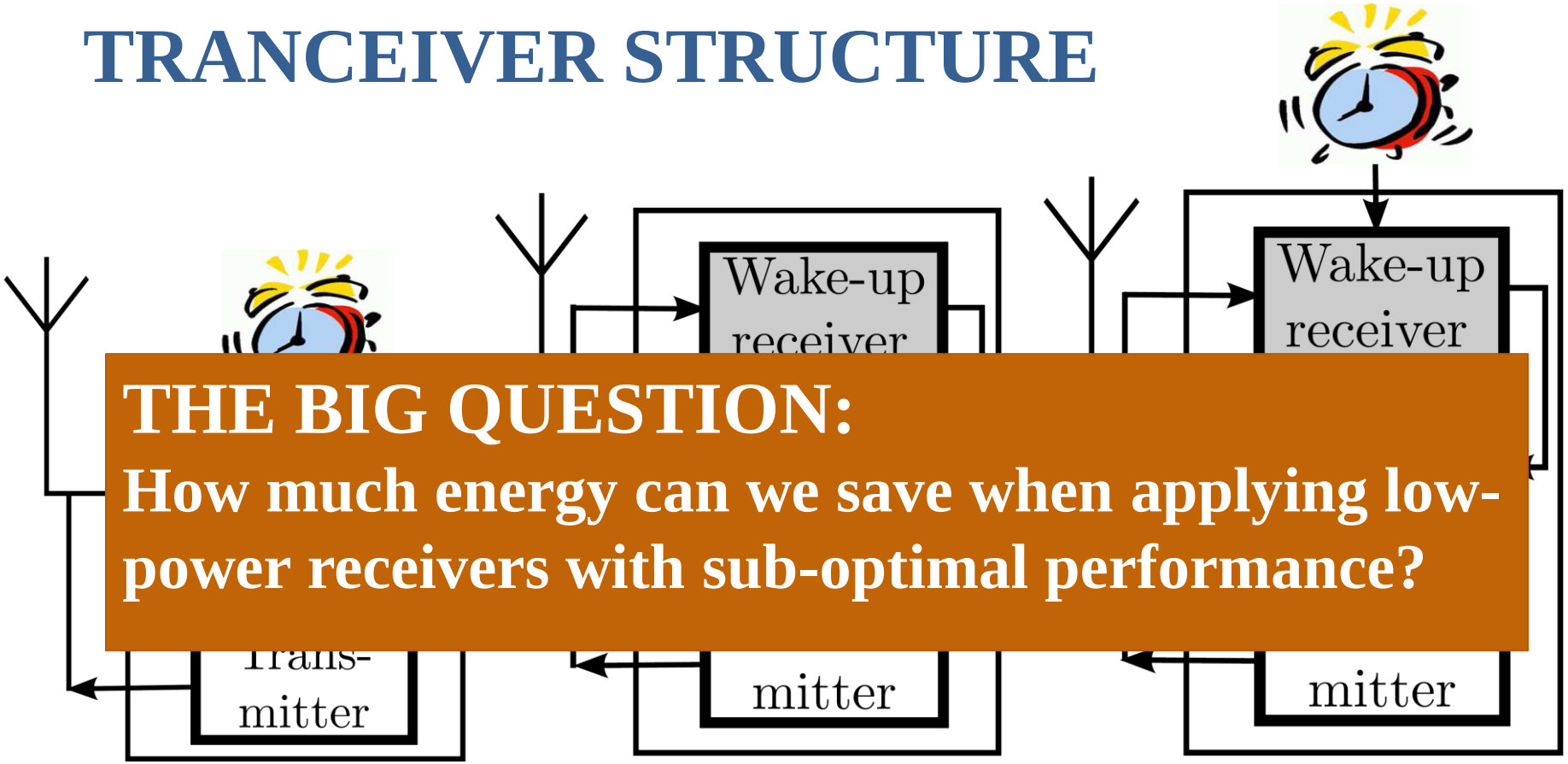
Energy sources are limited and potentially hard to replace.

Low-power transceivers and optimized communication protocols.

TRANCEIVER STRUCTURE



TRANCEIVER STRUCTURE



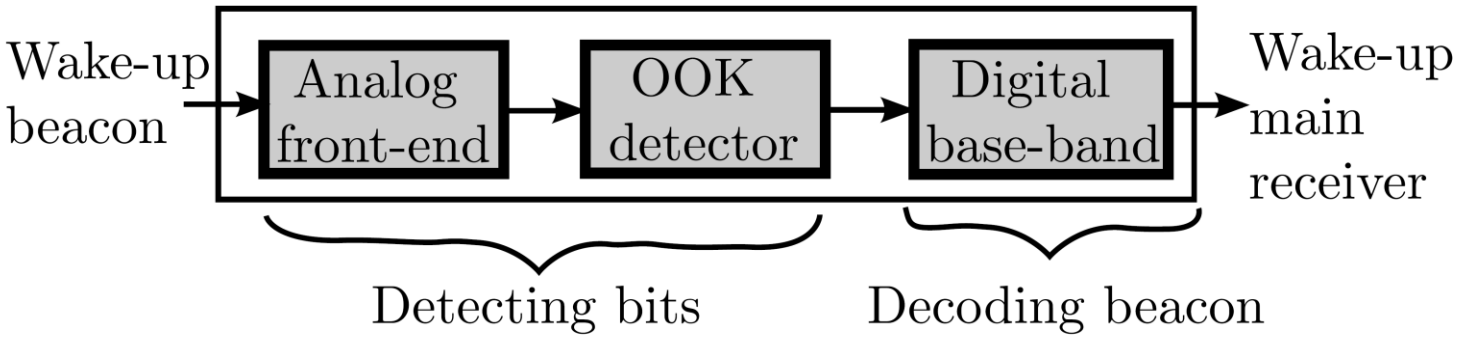
THE BIG QUESTION:

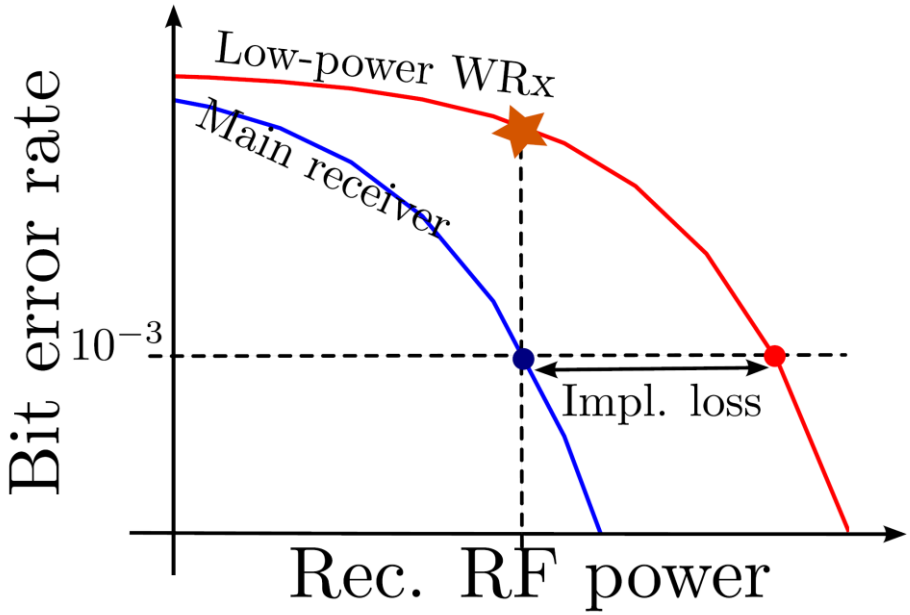
How much energy can we save when applying low-power receivers with sub-optimal performance?

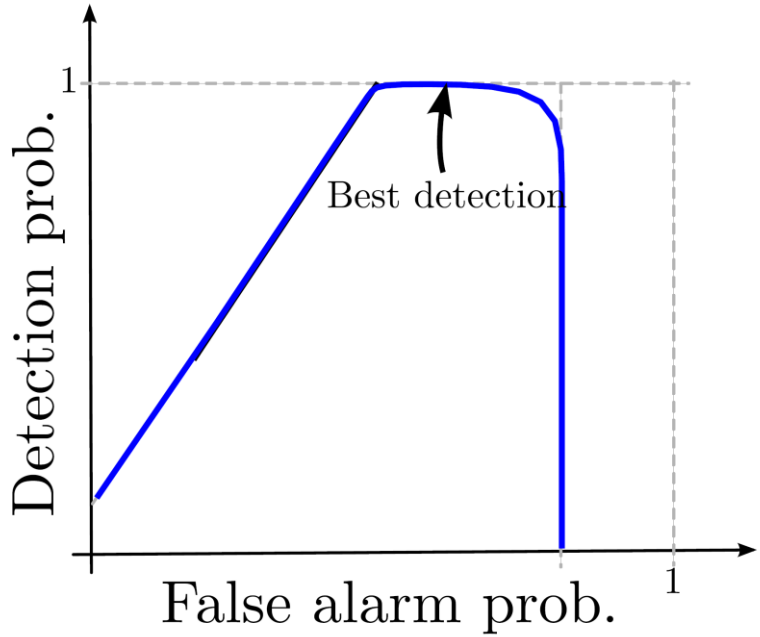
THE OPTIMIZATION PROCEDURE

- Analyze WRx performance.
- Calculate total energy cost for network.
- Optimize system for low energy.

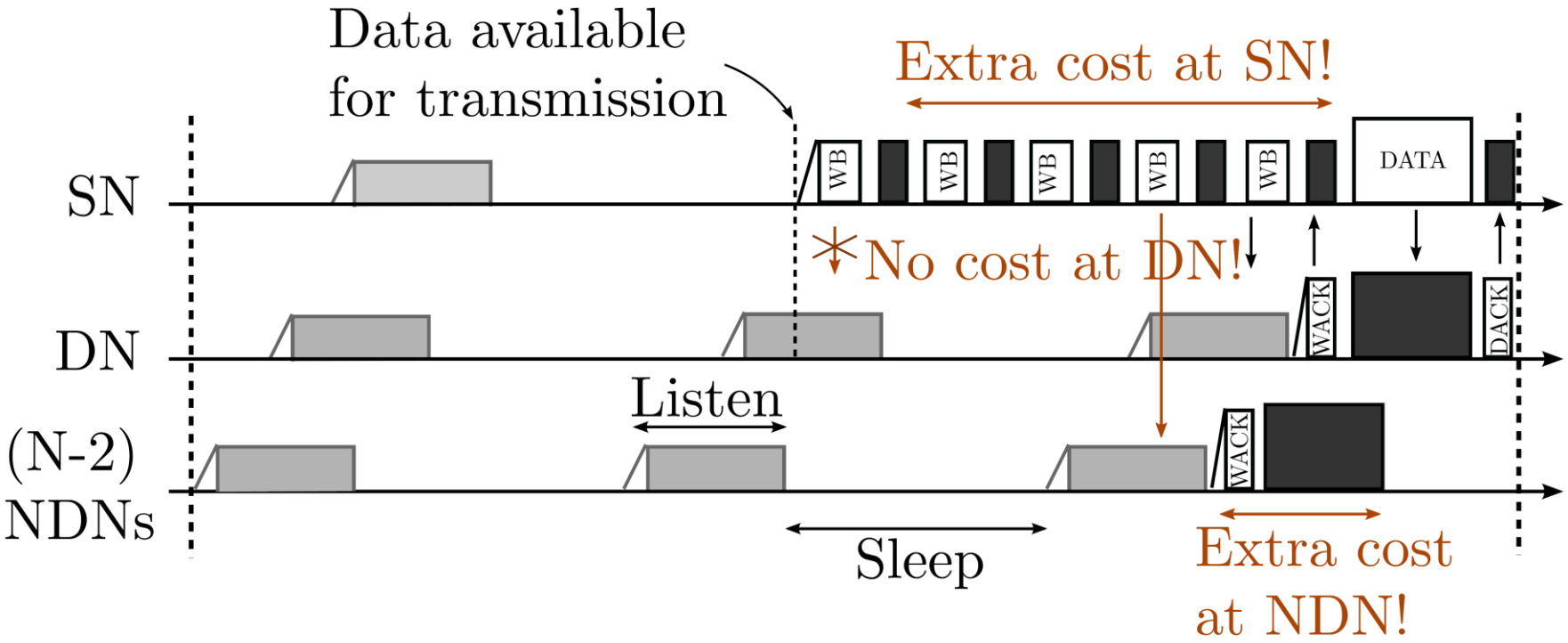
WAKE-UP RECEIVER PERFORMANCE ANALYSIS







ENERGY COST ANALYSIS



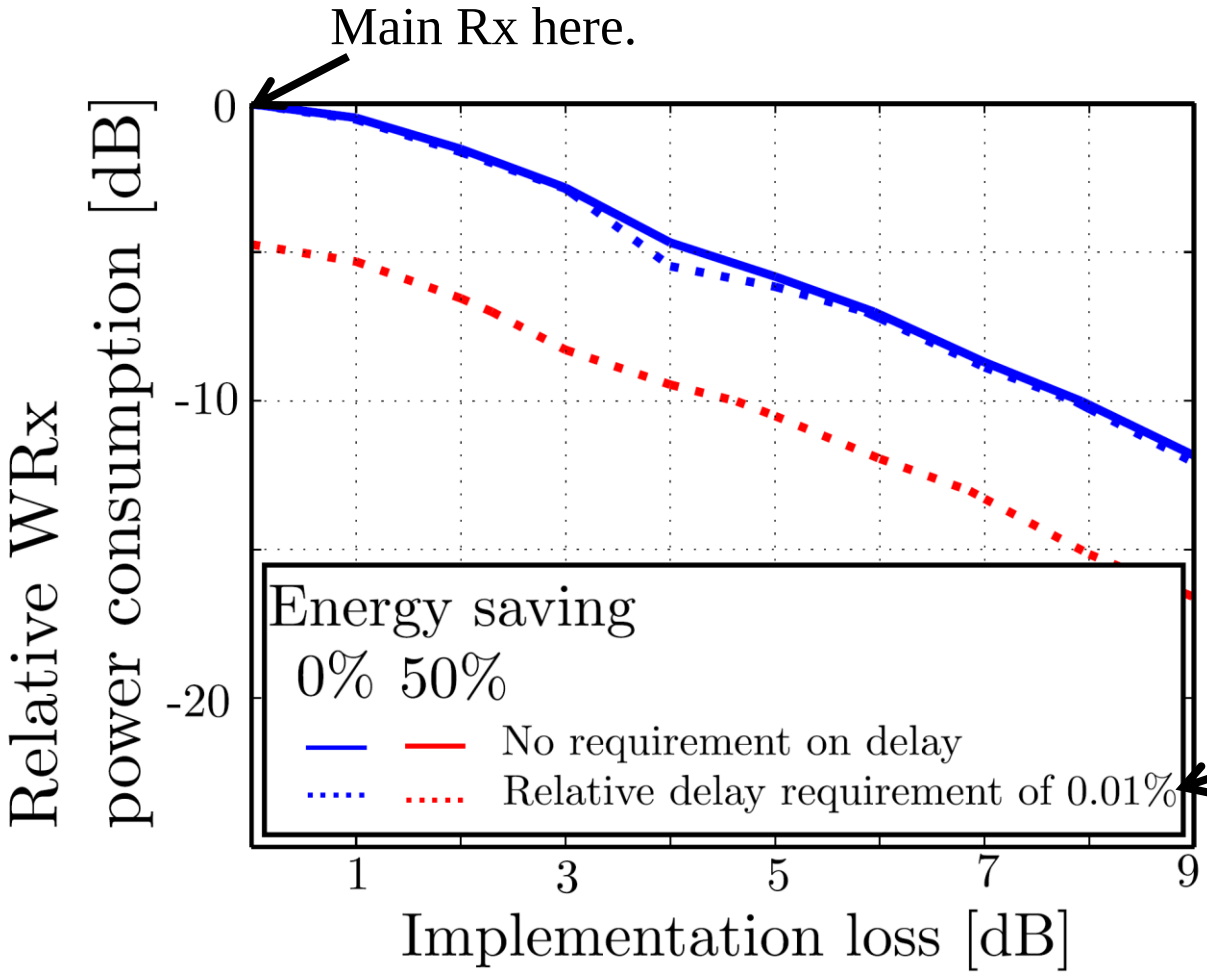
SN = Source Node

DN = Destination node

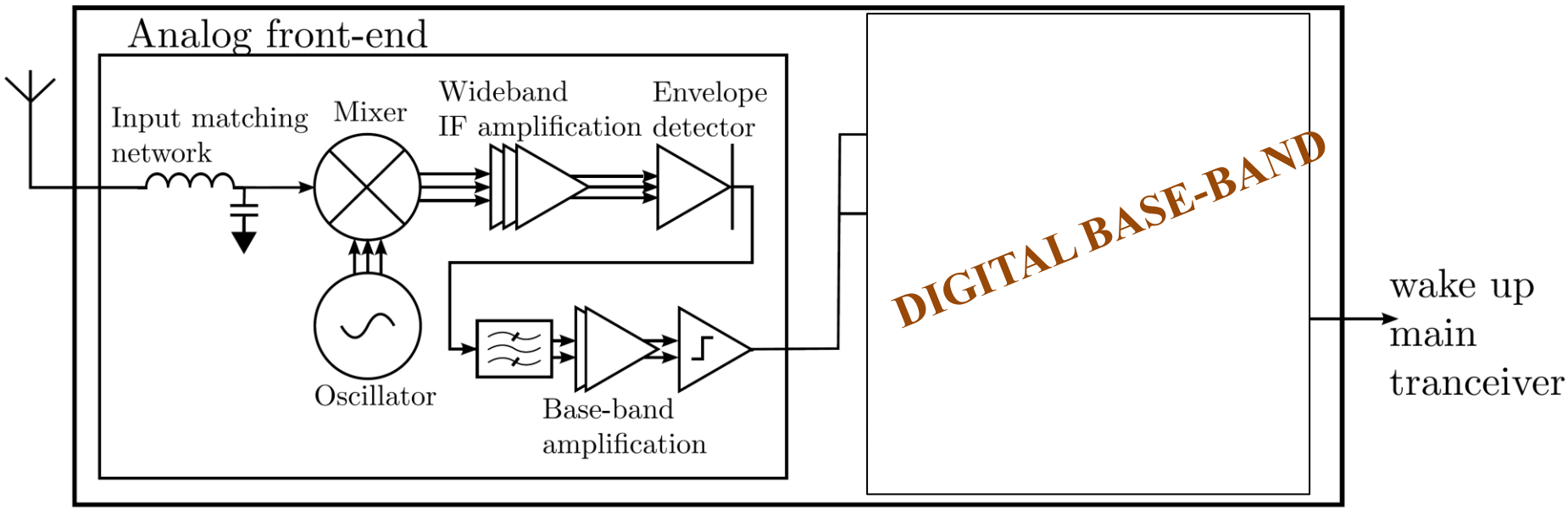
NDN = Non-Destination Node

THE GENERAL RESULT

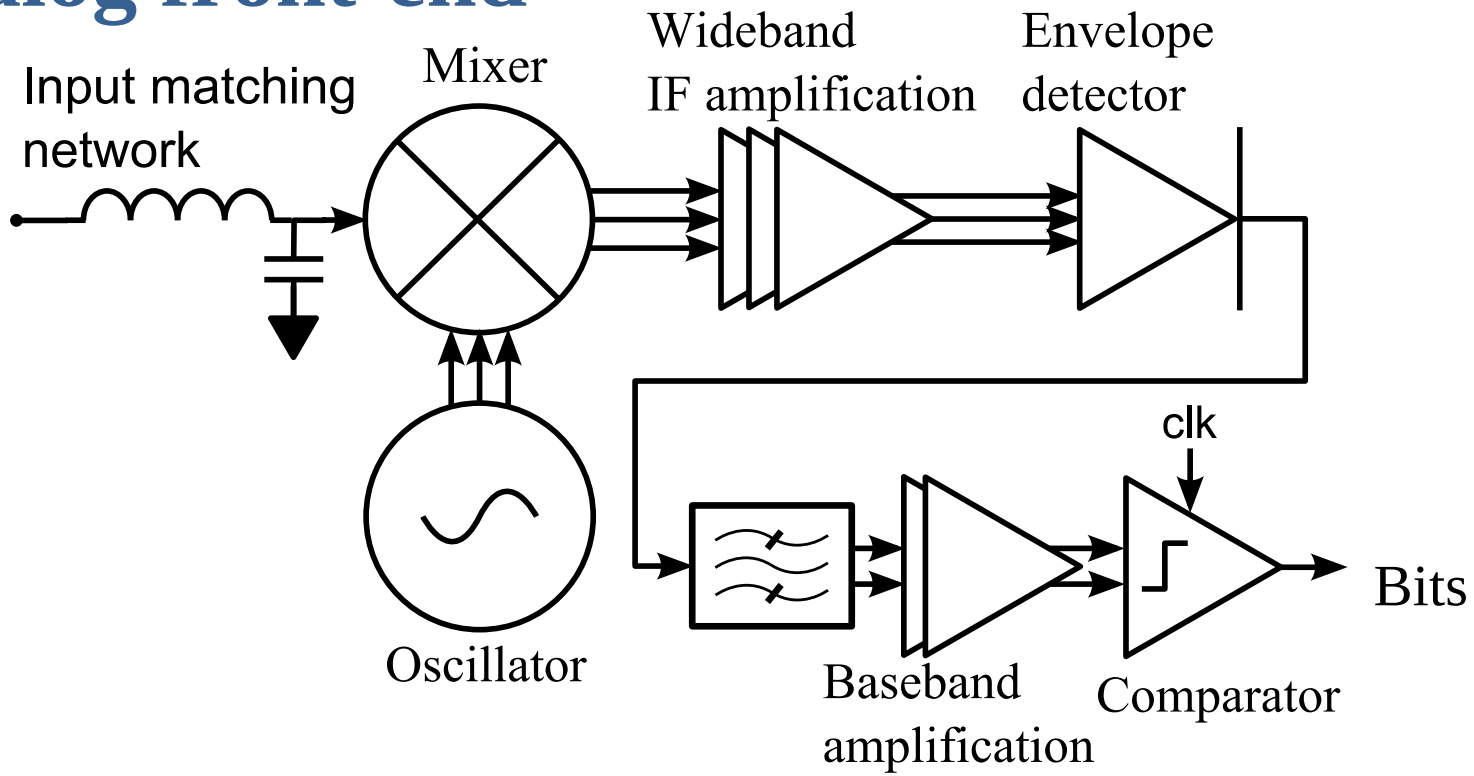
- **Applies to all possible WRx designs.**



FABRICATED DESIGN
Wake-up receiver



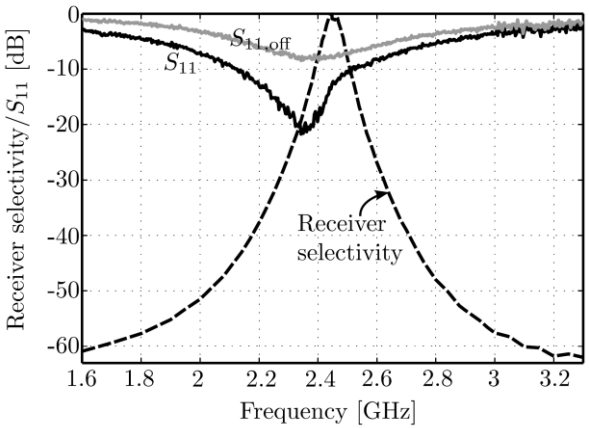
FABRICATED DESIGN
Analog front-end

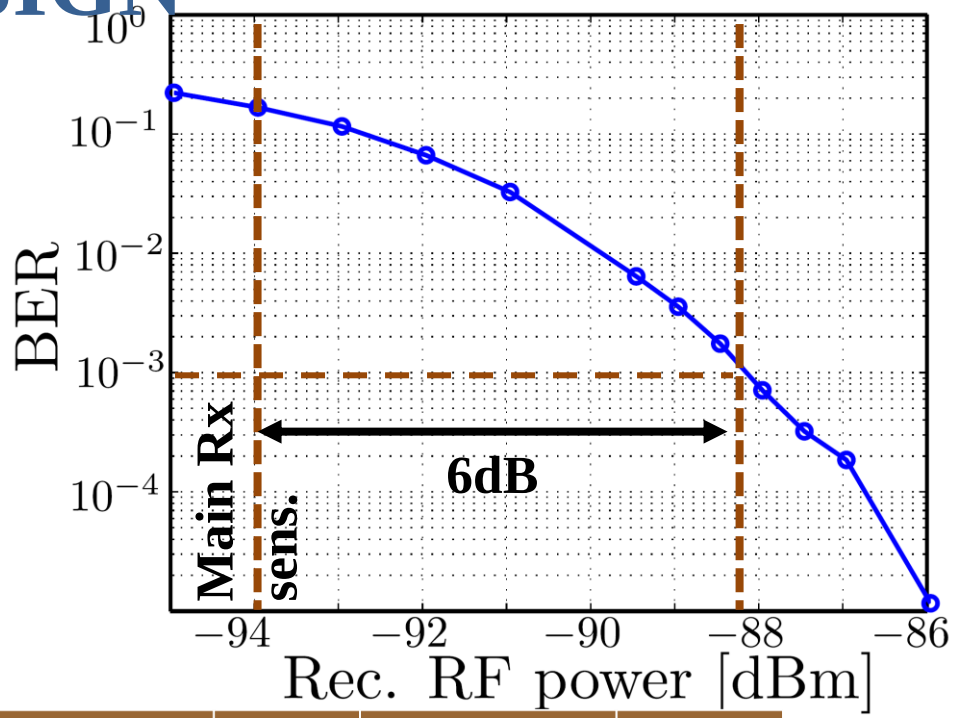


- 50Ω on-chip input matching with a compact inductor.
- Uncertain IF with a passive three-phase mixer improves sensitivity.

Work by Carl Bryant et al.

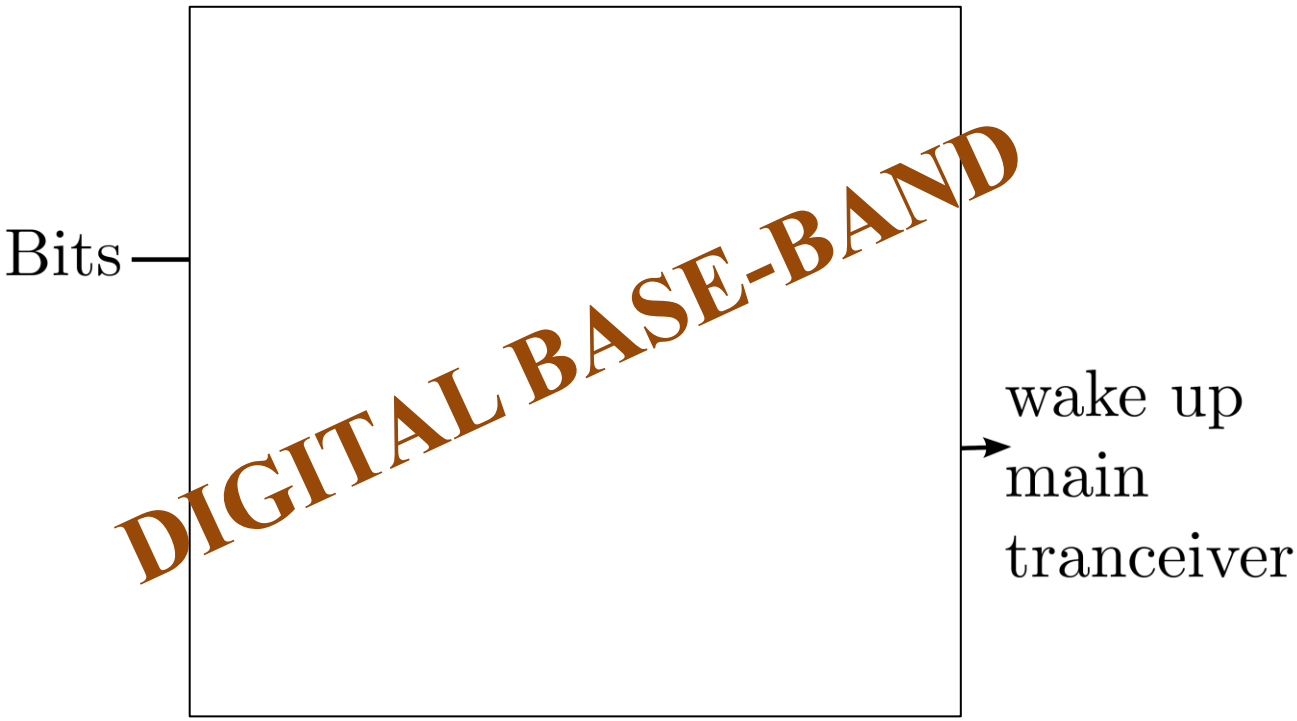
FABRICATED DESIGN
Analog front-end





	This Work		[1]		[5]	[6]		[7]
Technology (nm)	**65**		90		90	90		65
RF/IF detector	**IF**		IF		RF	RF		IF
Power cons. (μW)	**50**		52		51	123		415
V_{DC} (V)	**0.75**		0.5		0.5	1		1.2
Frequency (GHz)	**2.45**		2		2.4	0.915		2.45
Datarate (kbps)	**650**	**250**	200	100	10	100	10	250
P_{RF} (BER=10^{-3})	**-71**	**-88**	-70	-72	-69	-80	-86	-87
Efficiency (pJ/bit)	**77**	**200**	260	520	5100	1230	12300	1660

FABRICATED DESIGN
Sub-Vt digital base-band

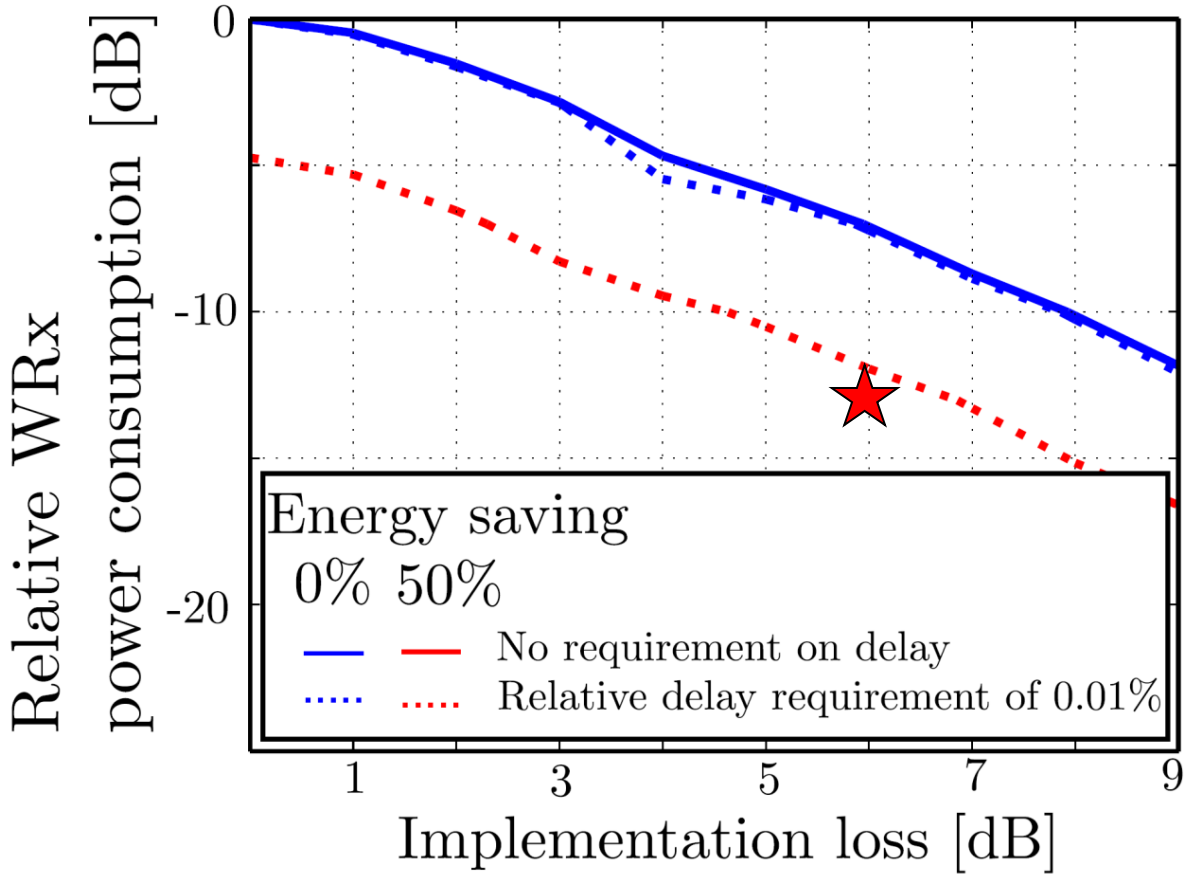


- The design provides large address-space scalability.
- 97% detection and 0.04% false alarm probabilities at 0.15 BER (M=63, K=15, and L=8).

FABRICATED DESIGN
Sub-Vt digital base-band

ENERGY MEASUREMENT

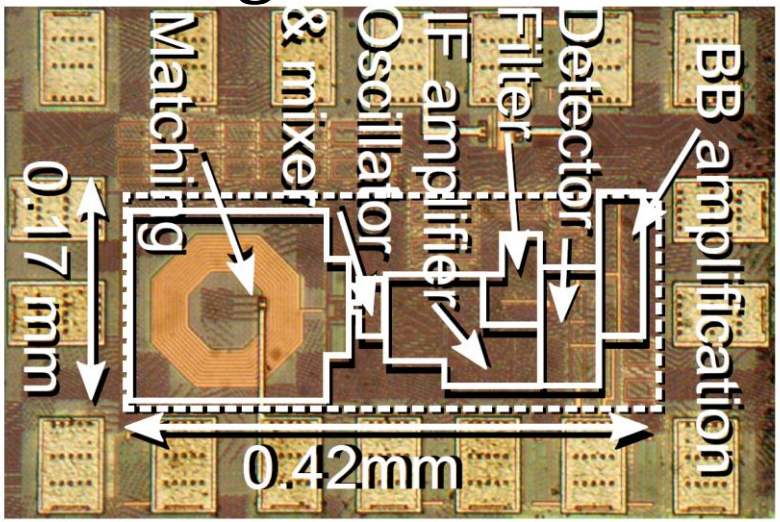
CONCLUSION



- The designed WRx saves more than 50% network power consumption.

DIE PHOTOS

Analog front-end



DIGITAL BASE-BAND

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