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Crying Wolf! Part II: Role of Technology Throughout the Hospital

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Disclosure: I am a paid R&D employee of Covidien Respiratory & Monitoring Solutions in Boulder, CO

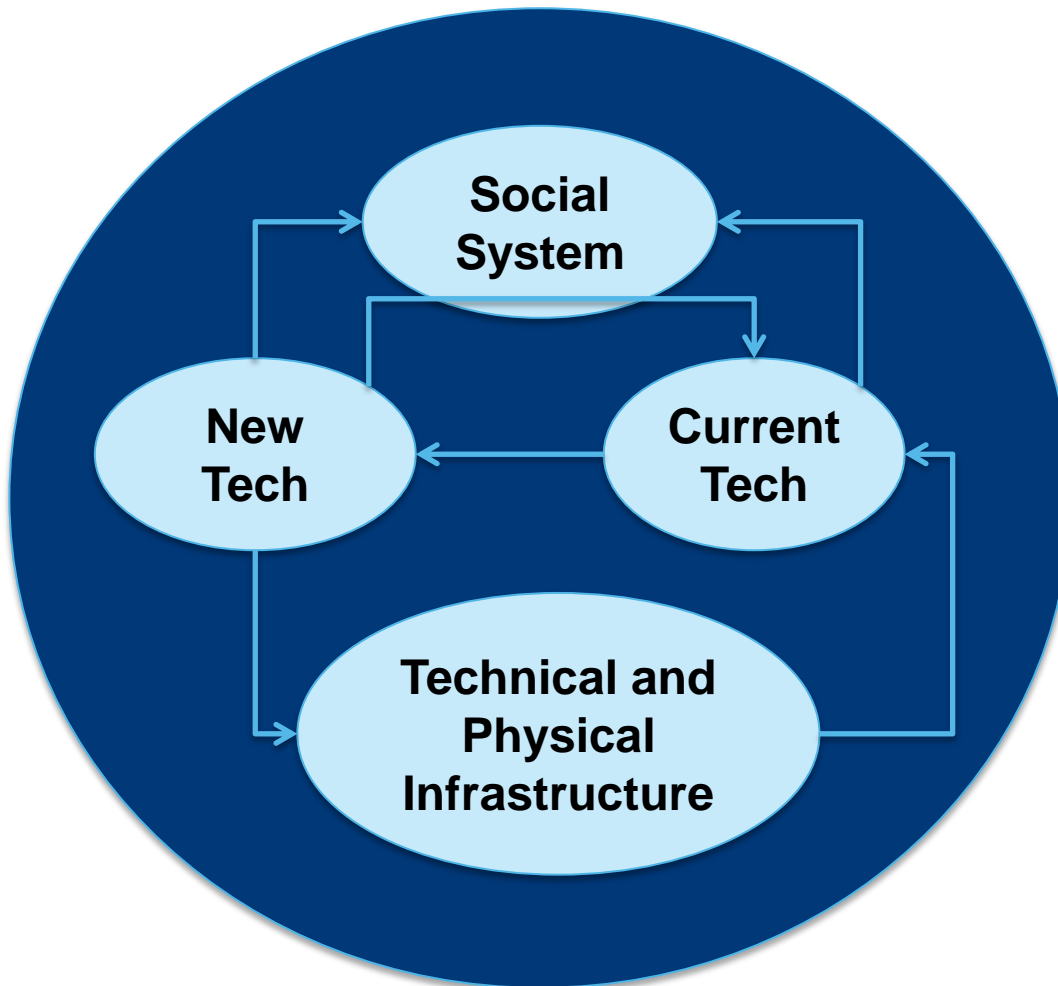
Outline

- I. Common Goal**
- II. Challenges & Opportunities**
- III. Technology: Smart Alarms**
- IV. Delivery of Information**
- V. Conclusions**

Complexity of the Environment



Goal: Effective Sociotechnical Interaction



Common Goal:

Leverage interactions to provide clinicians with early alerts that are directly linked to actions and interventions that improve patient care

Harrison, M.L., *et al.* Unintended Consequences of Information Technologies in Health Care—An Interactive Sociotechnical Analysis. *J Am Med Inform Assoc* 2007; 14:542-549.

Baseline: Where We Currently Stand

Bottom Line: majority of alarms do not result in clinical action¹

Closer Look from the ICU²:

	No. of Alarms	Freq (no/hr)	Duration (s/hr)	Effective Patient (%)	Effective Technical (%)	Ignored (%)	Ineffective (%)
Overall	1,214	6.07	197.5	5.3	17.8	40.7	36.2

1. Graham , K.C. & Cvach, M. Monitor Alarm Fatigue: Standardizing use of physiological monitors and decreasing nuisance alarms. *Am J Crit Care* 2010; 19:28-34.
2. Gorges, M., *et al.* Improving Alarm Performance in the Medical Intensive Care Unit Using Delays and Clinical Context. *Anesth Analg* 2009; 108:1546-52.

Challenges (Opportunities)

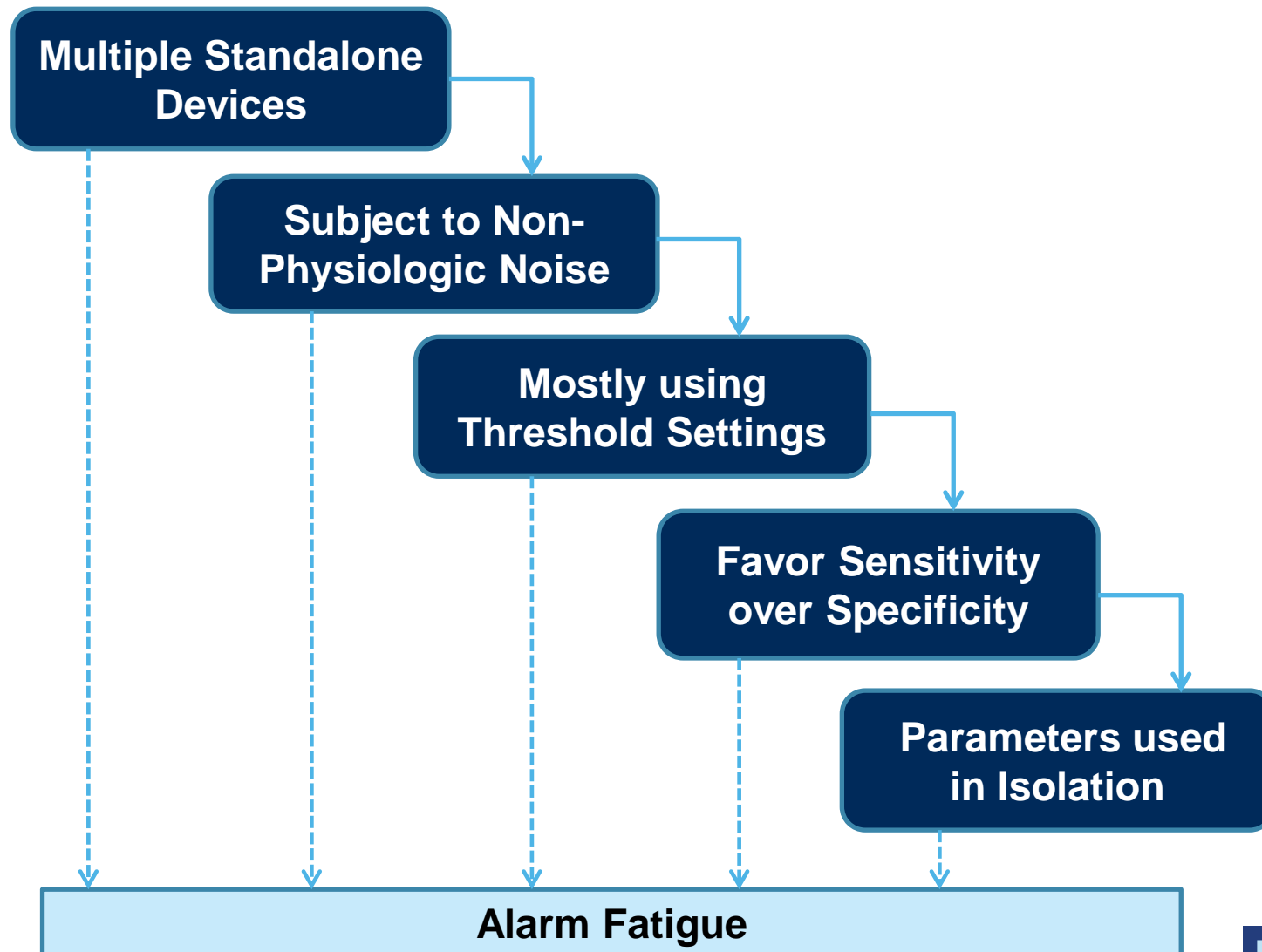
What does Success Look Like?

Imhoff et al.¹, reported that alarms & algorithms should:

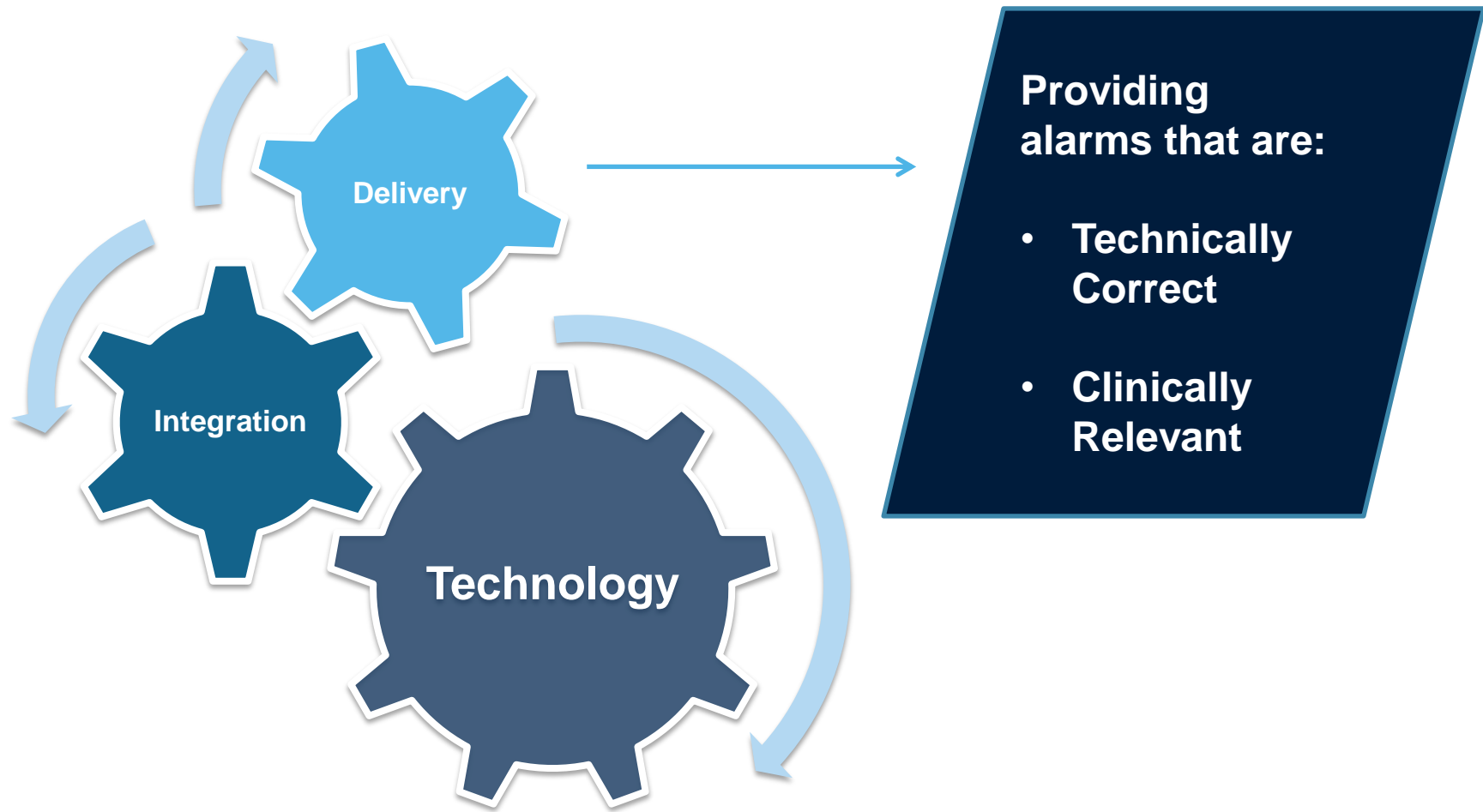
- Detect and alarm for all life-threatening situations
- Warn *prior* to life threatening-threatening situations
- Provide physiologic/diagnostic information about an alarm
- Differentiate between patient-related and equipment-related issues

1. Imhoff, M., *et al.* Smart alarms from medical devices in the OR and ICU. *Best Pract Res Clin Anaesthesiol* 2009; 23:39-50.

Current Technologies: Closing the Gap



The Future: Becoming “Smart” about Alarms



Single Parameter Threshold Alarms

Key Issues:

1. Non-physiologic (i.e., artifact) input may produce false alarms¹
2. Technically true alarms may be a result of clinically irrelevant threshold violations²

General Algorithmic Solutions:

- Discerning physiologic vs. non-physiological input
- Identifying clinically relevant changes

Non-Algorithmic Solutions:

- Instituting Alarm Delays
- Adjusting Threshold Settings (e.g., patient or AOC-specific settings)

1. Siebig, S., *et al.* Intensive care unit alarms—How many do we need? *Crit Care Med* 2010; 38: 451-456.

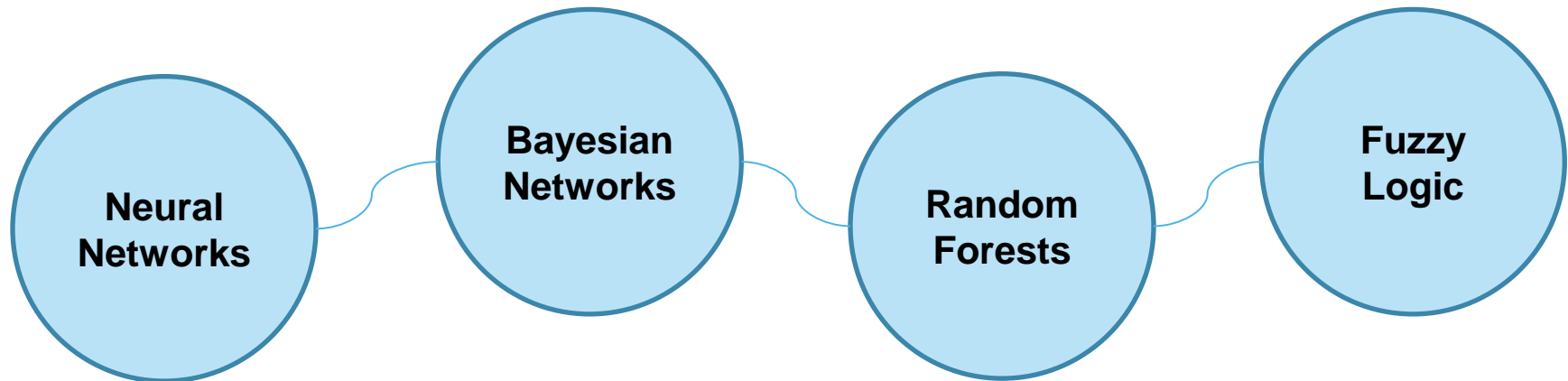
2. Cvach, M. Monitor Alarm Fatigue: An Integrative Review. *Biomed Instrum Technol* 2012; 46:268-77.

Algorithms: Multiparameter Integration

Issue: “Alarms from individual devices are not integrated with those from other devices in the same area.”¹

“Artificial Intelligence”: Algorithmic solutions can allow integrated, multiparameter analysis

Examples of Commonly Employed Methods²:



1. AAMI. Improving medical alarms systems. *Horizons (BI&T Supplement)* 2011; Spring: 5.

2. Schmid, F., et al. Patient monitoring alarms in the ICU and in the operating room. *Critical Care* 2013; 17:216.

Smart Alarms: Pulling it All Together

Clinical evaluation of algorithms for context-sensitive physiological monitoring in children

M. Dosani¹, J. Lim¹, P. Yang², C. Brouse², J. Daniels¹, G. Dumont² and
J. M. Ansermino^{1,*}

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Key Methodological Points¹:

- Monitored multiple parameters (EtCO₂, HR, Mvexp, NIAP, RR & SPO₂)
- Created an integrated algorithms based on trending data, not standard thresholds
- Identified physiologic “change points” and provided real-time feedback

1. Dosani, M., *et al.* Clinical evaluation of algorithms for context-sensitive physiological monitoring in children. *Br J Anesth* 2009; 102:686-691.

Smart Alarms: Pulling it All Together

Key Results¹:

22 “change points” detected per case (N = 38 cases), on average

- 61% of all rated “change points” were considered clinically significant
- < 7% were due to artifact
- 6 change points were missed

Usability was rated as “good” by 15 clinicians in study

Takeaway:

Demonstrates proof-of-concept for integrated alarming based on multiparameter, integrated alarms in OR

1. Dosani, M., *et al.* Clinical evaluation of algorithms for context-sensitive physiological monitoring in children. *Br J Anesth* 2009; 102:686-691.

Barriers to Resolve to Promote Adoption

Why we do not have—and will not have—the integrated and “smart” alarm systems that technology would allow us to have today

Frank E. Block, Jr., MD*

Virginia Commonwealth University, Richmond, VA, USA

Received 16 April 2012

Stakeholders¹:

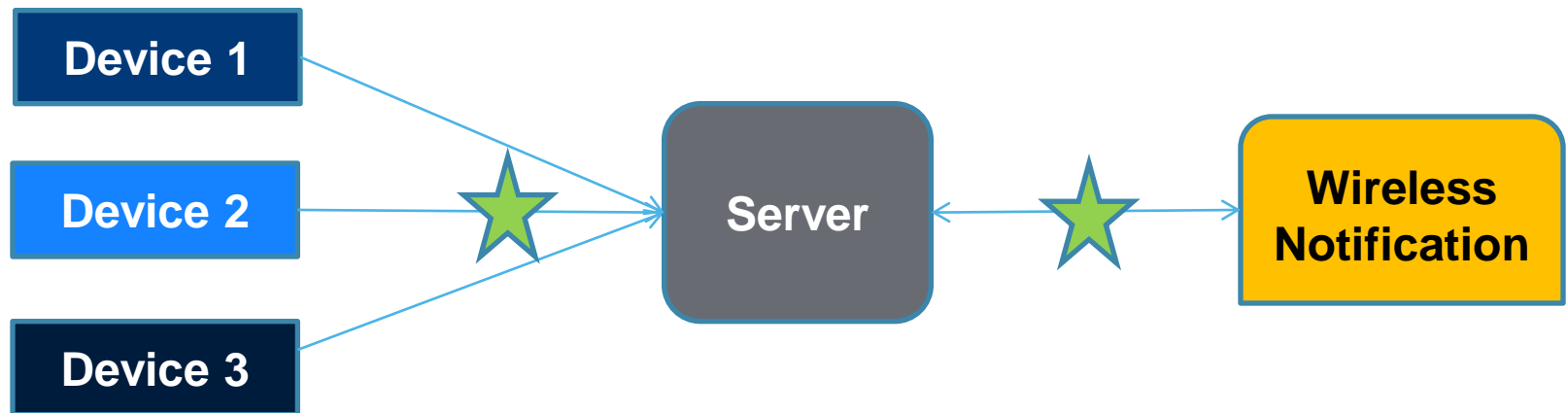
- Legal
- Regulatory
- Manufacturing
- Hospital Purchasing

1. Block, FE, Jr. Why we do not – and will not have- the integrated and “smart” alarm systems that technology would allow us to have today. *J Electrocardiol* 2012; 45:592-595.

Delivery of Information

Alarm Notification Models

Secondary (Third-Party) Alarm Notification Systems¹:



Strengths:

- Speed of notification
- Multiple devices
- Configurable & Wireless

Challenges:

- IT Infrastructure
- Regulatory considerations

1. Moorman, BA & Gee, T. Functional Basics of Third-Party Alarm Notification Systems. Biomed Instrum Techn 2011; 45:76-82.

Secondary Alarm Notification: Study

Use of Pagers With an Alarm Escalation System to Reduce Cardiac Monitor Alarm Signals

*Maria M. Cvach, DNP, RN, CCRN; Robert J. Frank, CET;
Pete Doyle, PhD, CHFP; Zeina Khouri Stevens, PhD, RN*

Methodology:

- Alarm escalation algorithm w/acknowledgement pager

Key Results:

- ↓ mean frequency/duration of high-priority cardiac alarms/monitored bed
- Improved nursing attitudes about clinical alarms

1. Cvach, M., et al. Use of pagers with an alarm escalation system to reduce cardiac monitor alarm signals. *J Nurs Care Qual* 2014; 29:9-18.



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Conclusions

- Goal of clinical alarms is to provide timely, relevant information that results in action/intervention
- Overall, current approaches are not effectively reaching goal
- “Smart” technology solutions hold promise, but widespread adoption has yet to be achieved
- Alarm notification models and human factors engineering have ability make current alarms more effective
- Further research is needed to determine best approaches and efficacy in clinical environment

Thank you

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