Improvements to information flow in the physician order tracking process

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BACKGROUND AND PROBLEM

Background:

- In an emergency department (ED), information flow is of high value:
  - The ability to react quickly directly affects the patients' well being.
  - One gap in the information flow is in the order tracking process.
- A local Toronto hospital (Sunnybrook Health Sciences Centre) has become a basis for the research study – since it's one of the largest ED settings in the province.

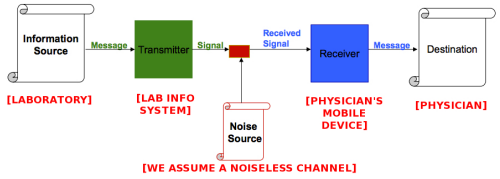
Problem Statement:

- The problem in the order tracking process is the lack of feedback that the physicians receive about their order status until the final results are available to them.
- Lack of feedback leads to problems for the physician workflow:
  - Tests may become lost without the ED staff being aware of the fact for a prolonged period of time.
  - Tests can be ordered multiple times if the information about their status has been unavailable to the physicians for too long.
- These discrepancies lead to:
- Losses in clinician time.
- An increased cost to the hospital and the Canadian healthcare system due to redundant tests being ordered.

ANALYSIS

Mathematical theory of communication:

- The effect of information flow inefficiencies on the ED processes aligns with the theory of communication developed by Shannon (1948) and Shannon and Weaver (1963).



- Focus on the amount of information that can be transmitted free of error through a communication channel, and optimizing information content in messages.

Model development:

- We shadowed 5 physicians in order to develop the model of the process:
  - The duration of each shift was 8 hours.
  - The types of the observed shifts were morning (8:00-16:00), afternoon (12:00-20:00), evening (16:00-00:00).
  - A total of 1213 orders were placed during the duration of the shadowing period.

MATERIALS AND METHODS

Simulation model for the current & future states:

- *Input data* were drawn from 42,343 laboratory tests that were tracked from March 1, 2012 to May 1, 2012 on a daily basis on a 24 hour per day schedule by Sunnybrook Health Science Centre's laboratory information system.
- In the current system, order feedback is sent upon order completion.
- In the future system, we proposed to send feedback to the physician at multiple points of the process:
  1. The order arrival in the laboratory has been delayed.
  2. The order has arrived in the laboratory.
  3. The processing of the order has been marked as delayed.
  4. The order has begun processing.
  5. The processing of the order has been delayed because sample has been re-ordered.
  6. The order has been completed.

Mathematical Theory of Communication framework:

- To calculate the measure of entropy, or expected value of information, the following formula is used:

$$H(s) = -\sum_{i \in \mathcal{S}} (P_i) \sum_{j \in \mathcal{S}} P_i(j) log_2 P_i(j)$$

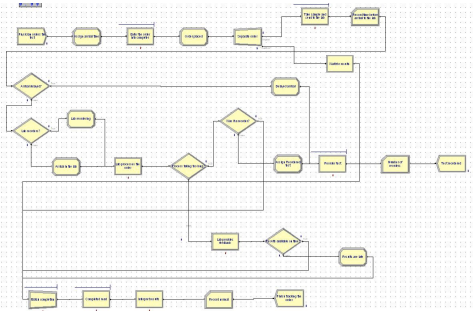
where i is the state, and Pi(j) is the probability of j given i as the previous state. States represent the points of feedback at which feedback can be sent to the physician.

- The probabilities for the states are extrapolated from the laboratory data set.
- To calculate the trade-off between the increase in the value of entropy and the "busyness of the physician" we use the following penalty function:

$$Z = -10(\sum_{i \in \mathcal{S}} (P_i) \sum_{j \in \mathcal{S}} P_i(j) log_2 P_i(j)) - 2n$$

Where n is the number of feedback messages that are sent to the physician, each taking two minutes to read. Larger Z values are desired.

Simulation of the future process-three new points of feedback:



RESULTS

Comparison of the current system's output to future scenarios

KPI	Curr. sys.	Arriv. Del.	Proc. Del.	Re-order	Comp-leted	Two msgs1	Two msgs2	Three msgs	Four msgs
T in sys.	2.74	**2.11**	2.29	2.49	2.55	2.23	2.28	2.66	2.48
T check.	0.39	**0.00**	0.10	0.05	0.27	0.09	0.11	0.10	0.08
T re-ord.	0.48	0.62	0.33	0.38	0.57	**0.29**	0.31	0.71	0.53

- "Two msgs1" and "Two msgs2" refer to "Arrival delayed" + "Process. delayed due to re-order" and to "Arrival delayed" + "Process. delayed" scenarios.
- "Three messages" refers to "Arrival delayed", "Process. delayed", "Process. delayed due to re-order", with scheduled checking for completion.
- "Four messages": "Arrival delayed", "Process. delayed", "Process. delayed due to re-order", "Completed" without scheduled checking for completion.

Expected value of information (entropy):

Model	H(s)	Z
Current system	0.03	−1.70
Arrival Delayed	**5.64**	**54.40**
Processing Delayed	1.22	10.20
Proc. Del. due to reorder	**4.32**	**41.20**
Two messages and checking 1	**7.47**	**70.70**
Two messages and checking 2	2.95	25.50
Three messages and checking	1.43	6.30
Four messages no checking	1.43	8.30

CONCLUSION

- The level of feedback in the order tracking process has an effect on the amount of time that the physicians spend actively looking for information, as well as on the total time that each laboratory order spends in the system.
- The best results are obtained by routing feedback to the physician about a "**Delayed arrival**".
  - Reduces the total time than an order spends in the system from 2.72 to 2.11 hours (22.99% decrease from the original value).
  - The second best result: two-message system where both "**Arrival delayed**" and "**Processing delayed due to re-order**" are pushed to the physician. The total time that an order spends in the system is 2.23 hours (18.63% reduction from the original value).
- According to the communication theory, a two-message feedback system in which "**Arrival delayed**" and "**Processing delayed due to re-orders**" are provided to the physician has high information content and second best Z value. These results can be used as guidelines for designing a comprehensive feedback system for the ED order tracking process.
- This study achieves its goal of understanding the information flow in the ED order tracking process and determining what improvements to the levels of feedback can improve it.