

Proactive Workflow Modeling for Healthcare Operation and Management

Presented by:

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INTRODUCTION

Sensor Network Infrastructure in Hospitals

Appliance/Bridge

- ❑ Collects the sensor data and calculates tag locations

Sensor Receivers

- ❑ Transmits the sensor data

Sensor Tags

- ❑ Broadcast low power radio messages
- ❑ Provide information about movement and status



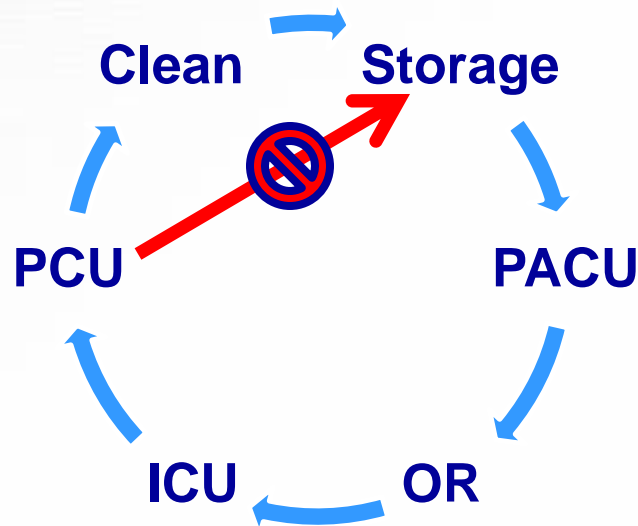
Device tag

Temperature Tag

Wearable Tag

Examples of Healthcare Workflow

- Typical process of medical devices:



- Doctors/Nurses must wash hands after medical operations.

Conventional approach

- ❑ **Inspecting detailed workflow logs: Managerially daunting**
- ❑ **Workflow logs: Heterogeneous in format and stored in different media, e.g., papers**
- ❑ **Maybe biased since passively provided by the personnel**

Our contribution

- ❑ **Integrated analysis of indoor location traces in the hospital environments**
- ❑ **Proactive and requiring minimum human intervention**
- ❑ **A promising complement for the workflow management tasks**

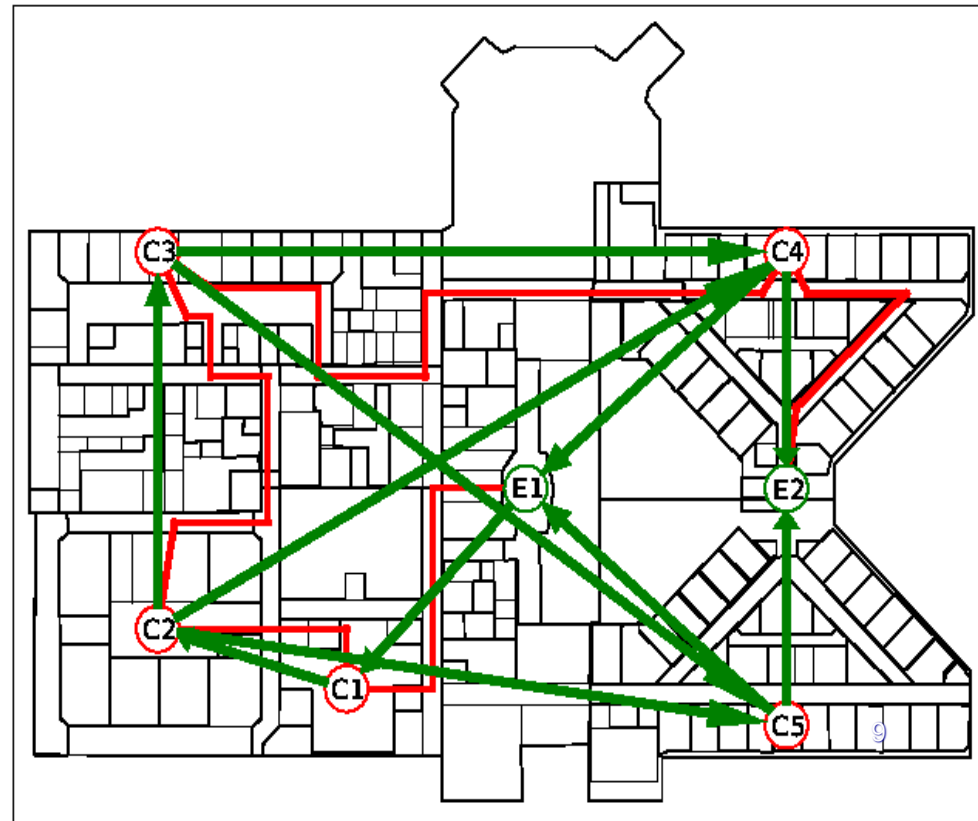
Research objective

- ❑ **Proactively unravel the workflow patterns hidden in the location traces:**
 - ❑ Construct workflow states
 - ❑ Estimate workflow transition probabilities
- ❑ **Apply the model for healthcare operation and management tasks**
 - ❑ Workflow monitoring
 - ❑ Workflow auditing
 - ❑ Workflow compliance inspection

STATE CONSTRUCTION

Workflow modeling with location traces

- ❑ How to describe the process in the red location traces? One infusion pump starts from the storage room in the basement to the elevator E1. After medical use (C1, C2, C3, C4) in this floor, it ends to the storage room from the elevator E2.
- ❑ **Workflow stages:**
 - ❑ Before C1: preprocessing
 - ❑ C1-C4: in-use stage
 - ❑ After C4: postprocessing
- ❑ **Workflow states:**
 - ❑ C1: PACU
 - ❑ C2: OR
 - ❑ C3: ICU
 - ❑ C4, C5: PCU



Algorithm for state construction

- We construct the workflow states based on activity densities:

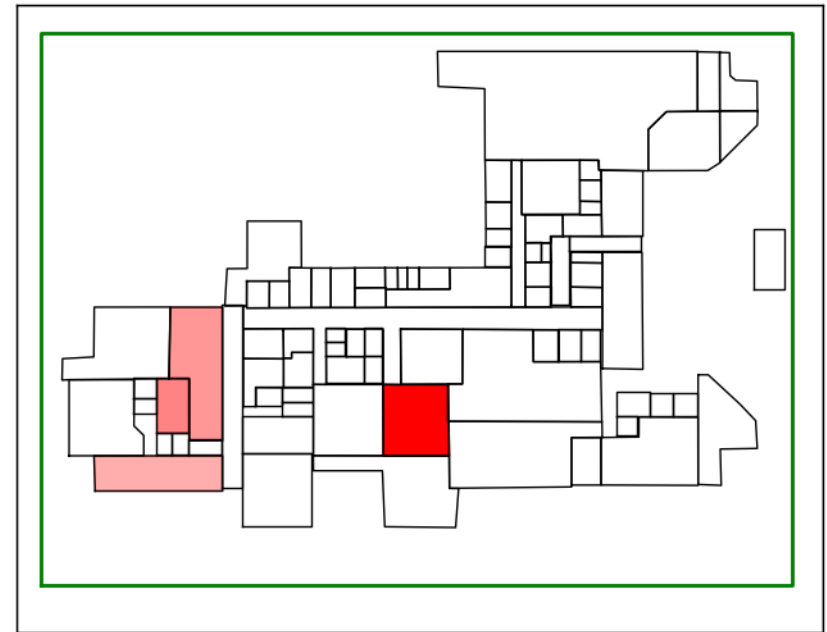
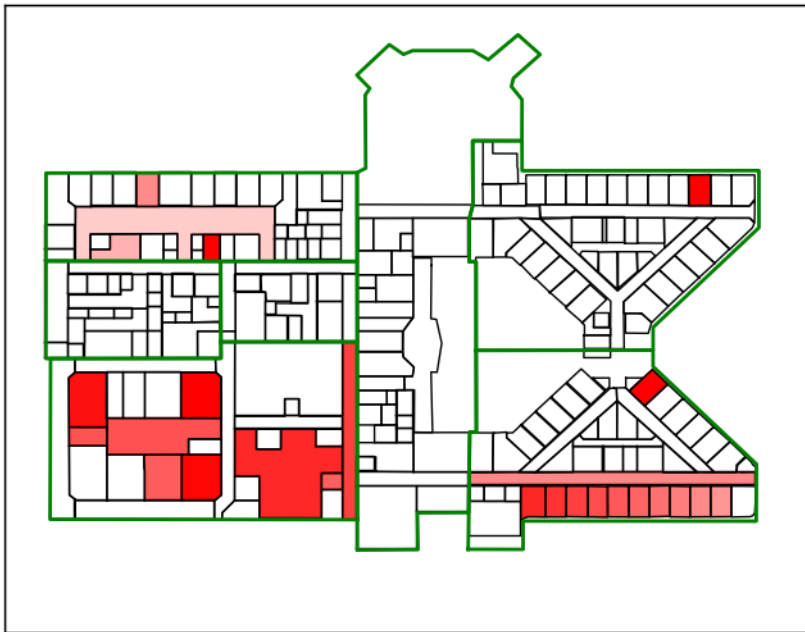
$$W(N(L_0)) = \frac{\sum_{L \in N(L_0)} w(L)(end - start)}{|N(L_0)|}$$

- The activity time $d = end - start$ of activity $(start, end, r_0)$ is weighted by:

$$W(L) = \Pr(T \leq d)$$
$$= \frac{|\{(start, end, r) | r = r_0, end - start \leq d\}|}{|\{(start, end, r) | r = r_0\}|}$$

Examples of state construction

- **2nd Floor: PACU, OR, ICU, PCU**
- **Basement: Clean room, Storage room**



TRANSITION ESTIMATION

Transition probabilities

Continuous time Markov chain (CTMC):

□ Parameters to be estimated:

□ Distribution of utilization durations of each workflow state: Exponential(-qt)

□ Transition probability between each pair of workflow states: P

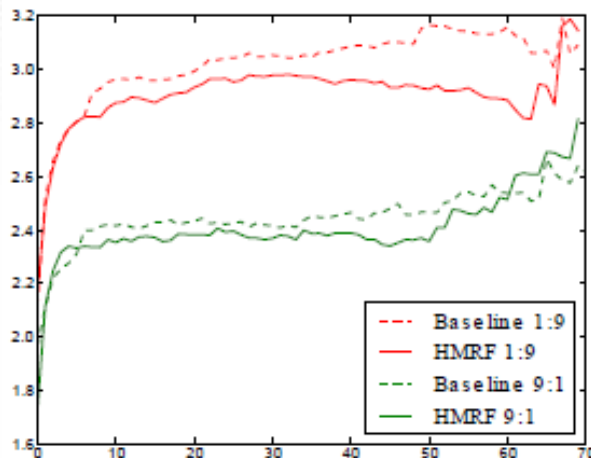
□ Multiple models for multiple types of objects: collaborative estimation.

Empirical Evaluation

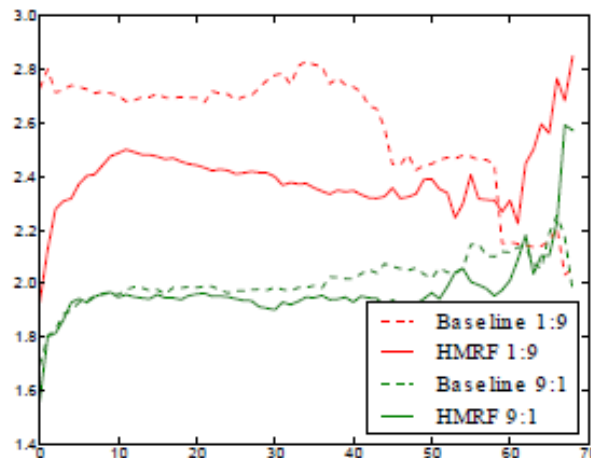
□ Average log-loss:

$$-\frac{1}{l} \log \Pr(Tr|P, q)$$

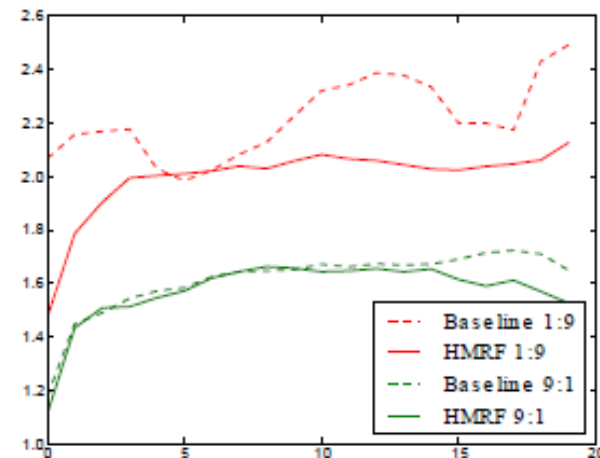
□ A comparison of different methods:



(a) Wheelchair



(b) Venodyne



(c) Feeding Pump

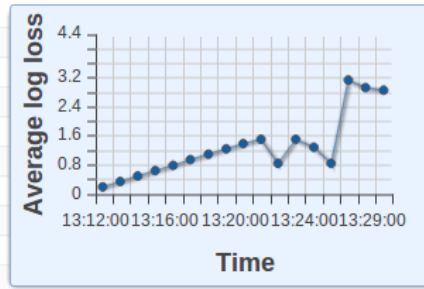
DEPLOYMENT

The prototype system

HISflow: A Healthcare Intelligence System for Workflow Operation and Management

- Real-time Explorer +
- Route Recommendation +
- Real-time Monitor -
- Business Insight +

Id	Type	Current Location			Status
		Building	Floor	Room	
49202	Feeding Pump	86738	5	526 Soiled Utility	From Storage
103054	Venodyne (SCD)	10123	10133	516 2 Bed Room	From Open Work Room
1359...	Wheelchair	10123	1076...	1-343 Exam	From 523
1340...	ETCO2	86738	10	Central Services - Cart W...	From Open Work Room
103020	Venodyne (SCD)	10123	10134	Corridor 6-603	From Central Services - Cart Wash
87547	Venodyne (SCD)	86738	9	304	Long waiting
1340...	ETCO2	10123	14623	Corridor L-1000J	From 321
105087	Venodyne (SCD)	10127	12663	435	From ICU 2
22705	Wheelchair	86738	8	Ambulatory Exit ED	From 1024 Room
37733	Venodyne (SCD)	86738	5	231 Open Work Room	Long waiting
103325	Venodyne (SCD)	10123	10134	Corridor 6-603	From Corridor L-1000J
103044	Venodyne (SCD)	10123	20028	2-204 2 Bedroom	Long waiting
156428	Venodyne (SCD)	10123	10138	1024 Room	From 526 Soiled Utility
119218	Venodyne (SCD)	10123	10133	506 1 Bed Room	From 2-204 2 Bedroom
114543	Venodyne (SCD)	10123	20028	2-200A Nurse Station S.I....	Long waiting
103067	Venodyne (SCD)	10123	10136	812 Patient Room	From 8-307 Pediatric Waiting
37730	Venodyne (SCD)	86738	9	315	From 812 Patient Room
103790	Venodyne (SCD)	10123	20028	2-204 2 Bedroom	From ICU 3
103317	Venodyne (SCD)	10123	20028	2-200A Nurse Station S.I....	From 1-533 BL-Plane Control
114542	Venodyne (SCD)	10123	10133	523 Renal Trans. 1 Bed R...	Long waiting
101690	Wheelchair	10123	10136	803 H/C Patient Room	From 1-343 Exam
1340...	ETCO2	86738	9	258 Soiled Utility	Long waiting
103162	Venodyne (SCD)	10123	10133	514 2 Bed Room	From 258 Soiled Utility
103074	Venodyne (SCD)	10123	10139	1105 1 Bed Room	From 514 2 Bed Room
103070	Venodyne (SCD)	10123	10138	10-154	Long waiting
136193	Wheelchair	10123	14623	Corridor L-101	From 10-154
62008	Feeding Pump	10123	10138	10-253 C Arm Stor.	From Corridor L-101
103156	Venodyne (SCD)	10123	10135	719 1 Bed Room	Long waiting
1340...	ETCO2	10123	14623	L-304 Medication	From 719 1 Bed Room
1340...	PCA	10123	1076...	1-533 BL-Plane Control	From 822 Patient Room



Status Auditor

Status Explorer

Thanks!