J-PLOS: Java-based Platform for Learning Order Sets

Daniel Gartner*
School of Mathematics, Cardiff University
Cardiff, Wales, United Kingdom
gartnerd@cardiff.ac.uk

Yiye Zhang†
Weill Cornell Medical College, Cornell University
New York, New York, USA
yiz2014@med.cornell.edu

Rema Padman‡
The H. John Heinz III College, Carnegie Mellon University
Pittsburgh, Pennsylvania
rpadman@cmu.edu

ABSTRACT

Order sets are a critical component that are included in hospital information systems to reduce clinician workload. They represent clustered order items, such as medications and treatments prescribed at hospital admission, which are administered to patients during their hospital stay. In this project showcase track, our aim is to demonstrate a platform that allows practitioners to learn order sets from usage data and to compare their current order set with heuristic and optimal order set configuration. Optimal order sets can be determined using two tailored mathematical programming formulations of a clustering problem. Because of the computational complexity of the problem, there is also a quick and heuristic option to generate order sets using machine learning approaches linked with the mathematical programs.

CCS CONCEPTS

• **Information systems** → **Clustering**; • **Mathematics of computing** → **Combinatorial optimization**; • **Applied computing** → **Operations research**;

KEYWORDS

Healthcare Information Systems; Health Informatics/Health Information Systems/Medical IS; Analytical Modeling; Heuristics

ACM Reference Format:

Daniel Gartner, Yiye Zhang, and Rema Padman. 2018. J-PLOS: Java-based Platform for Learning Order Sets. In *Proceedings of Project Showcase Track (KDD'18).* ACM, New York, NY, USA, 2 pages.

1 RESEARCH PROJECT DESCRIPTION, GOALS AND PARTNERS

In healthcare information systems, Computerized Physician Order Entry (CPOE) has proven to be effective in increasing patient safety, reduce medication errors and costs (Nuckols et al. [6]). Specifically, order sets support clinicians in high risk situations by serving as expert-recommended guidelines, reducing prescribing time by making complex ordering easier, increasing physician compliance with the current best practice and playing a vital role in reducing excessive ordering (Goldszer et al. [5]). A characteristic of order sets is that specific orders can be predetermined to be "pre-set" or "defaulted-on" whenever the order set is used while others are "optional" or "defaulted-off" (though there is typically the option to "deselect" defaulted-on orders in a given situation), see Gartner et al. [4]. For instance, the 'Asthma Admission Order Set' shown in Figure 1 groups together order items for Asthma patients upon admission.

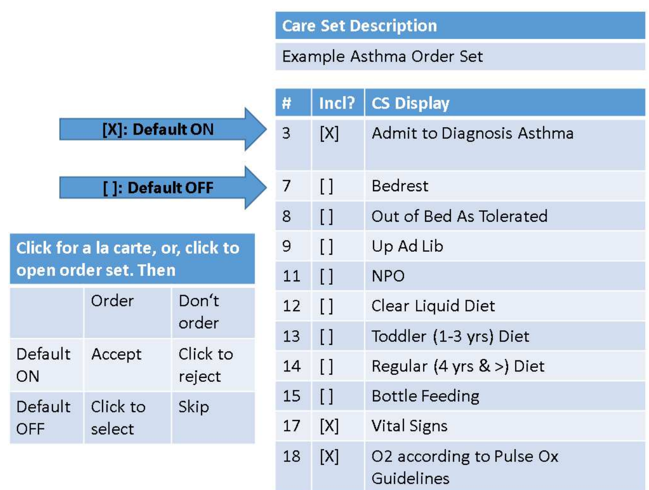

Figure 1: Example asthma admission order set

When a clinician prescribes orders to patients, an order item in order sets can be defaulted ON or OFF according to clinical relevance and frequency of use. An order item can be part of multiple order sets. Despite the benefits of order sets, historical data indicate a tremendous variability in order set usage by physicians, driven largely by the diversity in patient population, physician experience, and system usability (Zhang et al. [7]). Within CPOE, physicians can search for particular orders by typing the order names and the search result includes all a la carte orders and order sets that match the keyword because order set usage is not mandatory. A la carte orders are individual orders that physicians choose to enter without using order sets. Intuitively, ordering a la carte items takes more time compared to order sets because they have to be searched for and entered one by one. Some orders are standalone items

*Dr. Daniel Gartner is the Aneurin Bevan Lecturer of Operational Research in the School of Mathematics at Cardiff University, United Kingdom
†Dr. Yiye Zhang is Assistant Professor of Healthcare Policy and Research at Weill Cornell Medical College, Cornell University, USA
‡Dr. Rema Padman is Professor of Management Science and Healthcare Informatics in the Heinz College of Information Systems and Public Policy at Carnegie Mellon University in Pittsburgh, USA

KDD'18, August 2018, London, United Kingdom

and a la carte is the only way to prescribe them. Yet, reasons for ordering a la carte items instead of order set items come from a physician's disagreement with order set content, unfamiliarity with order sets, inconsistency of order set content with current best practices, and at times, a simple need for only one or two orders. Ordering efficiency decreases when order sets contain items that do not match the workflow or the patient's condition, forcing physicians to go through long lists of orders to determine each item's relevance to particular patients, and eventually rely on a la carte orders which are time-consuming and subject to errors (Zhang et al. [7]). Size of order sets is at least 2, varying depending on their purpose.

This project aims to address these challenges by proposing an order set optimization platform that allows clinicians to evaluate the current setting in their CPOE system and compare it with heuristic and optimal approaches as described in Gartner et al. [3]. The project started in 2012 when a large childrens university hospital in the U.S. approached a group of researchers at the H. John Heinz III College at Carnegie Mellon University to evaluate and potentially improve the order set configuration currently in use. The team developed heuristic and optimal approaches which demonstrated in several studies that the current configuration can be outperformed on a variety of performance metrics, see Gartner et al. [4] and the references therein.

2 AN ORDER SET OPTIMIZATION PLATFORM

Gartner et al. [4] started to develop a Java-based order set optimization prototype platform with the aim to compare current order set usage with Clustering and Integer Programming approaches. For a video that shows the tool, see [1]. Figure 2 shows the software architecture which contains design patterns of Gartner and Padman [2]'s E-HOSPITAL platform.

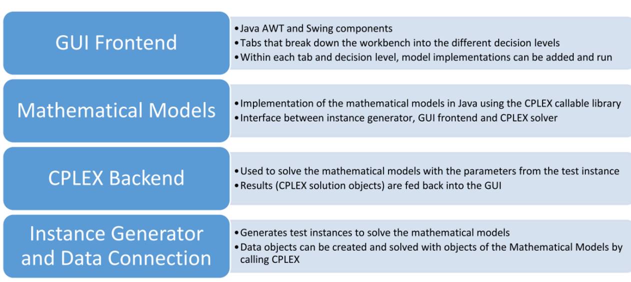

Figure 2: Implementation architecture

The graphical user interface (GUI) front-end communicates with the mathematical models using the IBM CPLEX callable library as a back-end. Instance generators and a database connection are used to import the hospital's current order set configuration as well as the patient-dependent item demand.

We extended Gartner et al. [4]'s work in two ways: First, we incorporated multiple clinical conditions (acute, chronic, and surgical). Second, we implemented the time-independent order set optimization models. Figure 3 shows the latest version of the platform.

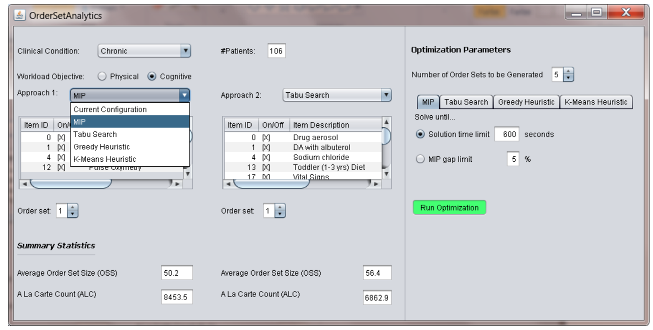

Figure 3: Order set optimization platform

On the left-hand side of the platform, the user can choose between the clinical conditions and whether she wants to optimize a physical or cognitive workload objective. The difference between both objectives is that the physical objective minimizes mouse clicks and the other one minimizes the mental workload associated with the order and order set prescription. Using the next drop-down menus, the user decides which approaches she wants to compare. For example, the MIP can be compared with the Tabu Search Algorithm. As can be seen, in the solution provided by the Tabu Search item number 0 which is the prescription of a drug aerosol is defaulted ON because it is marked with an "X". In fact, further order items such as "Pulse Oxymetry" are defaulted ON, too. Using the spinner below the table, the user can choose the next order set number. Below each solution approach, summary statistics on metrics introduced by Gartner et al. [4] are provided.

On the right-hand side of the platform, the user controls the number of order sets to be generated as well as parameters for the solution process. These depend on the chosen solution approach (MIP, Tabu Search, Greedy Heuristic and K-Means Heuristic). An explanation how these approaches work is available in Gartner et al. [3] and Gartner et al. [4]. For example, if the problem is solved using the MIP the user can specify whether the solver should stop after a specific number of seconds. Alternatively, a limit can be set.

REFERENCES

[1] Daniel Gartner. 2018. Order Set Optimization Platform. https://www.youtube.com/watch?v=wID0Kc_olIA. [Online; accessed 1-June-2018].

[2] D. Gartner and R. Padman. 2017. E-HOSPITAL – A Digital Workbench for Hospital Operations and Services Planning using Information Technology and Algebraic Languages. *Studies in Health Technology and Informatics* 245 (2017). MEDINFO 2017 conference proceedings.

[3] D. Gartner, Y. Zhang, and R. Padman. 2015. Workload Reduction Through Usability Improvement of Hospital Information Systems – The Case of Order Set Optimization. *ICIS Proceedings 2015* (2015).

[4] D. Gartner, Y. Zhang, and R. Padman. 2017. Mathematical Programming for Cognitive Workload Reduction in Order Set Optimization. *Health Care Management Science* (2017). Online first, doi:http://dx.doi.org/10.1007/s10729-017-9406-6.

[5] R.C. Goldszer, K. Ratzan, M. Csete, N. Nanes, C. Love, L.X. Cubeddu, D. Farcy, A. Shrestha, and T. Gillette. 2017. Impact of order set use on outcome of patients with sepsis. *Applied Informatics* 4, 1 (05 Jan 2017), 2.

[6] T.K. Nuckols, C. Smith-Spangler, S.C. Morton, S.M. Asch, V.M. Patel, L.J. Anderson, E.L. Deichsel, and P.G. Shekelle. 2014. The effectiveness of computerized order entry at reducing preventable adverse drug events and medication errors in hospital settings: a systematic review and meta-analysis. *Systematic Reviews* 3, 1 (2014), 56.

[7] Y. Zhang, R. Padman, and J.E. Levin. 2014. Paving the COWpath: Data-driven design of pediatric order sets. *Journal of the American Medical Informatics Association* 21, e2 (2014), e304–e311.