A technique for object-centric compliance checking

Technical Report

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1 Preliminaries

Below are three case studies proposed by the community, along with the Compliance Requirements (CRs) that illustrate the applicability of our Object-Centric Compliance Checking technique. All the cases are simulated object-centric event log.

Logistics (LOG) [2]. Captures logistics operations. The logistics process involves the movement of goods from the production site to the customer. It begins with the registration of a customer order, followed by the creation of a transport document. The logistics service provider is then contacted to arrange the transport of goods to a seaport, involving booking vehicle capacities and ordering empty containers. The goods are packed into handling units, loaded onto trucks, and transported to a terminal. At the terminal, containers are weighed and stored before being loaded onto vehicles for departure. Occasionally, delays necessitate rescheduling containers for the next available vehicle.

Order Management (OM) [1]. Focuses on the order management processes. This process encompasses the entire cycle of managing customer orders, from registration to shipment. Customers place orders for products, which are then assigned to sales representatives for processing. The sales department confirms orders and processes payments, while the warehousing department checks stock availability and reorders items if necessary. Items are picked, packed, and prepared for shipment. Shipments are managed by a separate team, and the process ensures that deliveries are completed successfully.

Procure-to-Pay (P2P) [3] Details the entire procurement process from purchase to payment. The P2P process starts with the creation of a purchase requisition and proceeds through approval, vendor selection, and purchase order creation. Goods receipts and invoice processing follow, culminating in the payment execution. Special behaviors in the process include maverick buying (unauthorized purchases), duplicate payments, and lengthy approval processes. This process utilizes SAP transactions to simulate real-world scenarios.

Table 1 presents some statistics and specifications of the events logs associated with the case studies. Further information on the synthetic events log can be found at `https://www.ocel-standard.org/event-logs/overview/`.

Case study	Event types	No. events	Object types	No. objects
LOG	14	35761	7	14013
OM	11	21008	6	10840
P2P	10	14671	7	9543

Table 1. Overview on object-centric sample event logs.

Following, Table 2, are the object-centric CRs extracted from the presented case studies. CRs, in general, are compliance rules that affect the processes.

id	Specification	Case study
cr1	A Customer cannot create more than 5 orders	LOG
cr2	A Transport Document is mandatory i.o.t. starting handling an order	LOG
cr3	The handling of an order should not exceed 2 working days	LOG
cr4	In the last week, a maximum of 10 containers is accepted for delayed departure	LOG
cr5	After order is confirmed, a Payment Notification should be delivered if the payment has not been performed within 2 days	OM
cr6	Only "Sales" employees can access customers data	OM
cr7	Does maverick buying (the order is placed without proper approval, and created in the system only after the invoice is received) happen in the process	P2P
cr8	Duplicate Payments: An error leading to the same invoice being paid multiple times	P2P
cr9	Lengthy Approval Process: Delays in approving purchase requisitions or purchase orders, which might lead to operational inefficiencies	P2P

Table 2. Compliance requirements extracted from the case studies.

2 Object-Centric Compliance Checking Technique

Following are the Object-Centric Compliance Rules (OCCRs) defined for each CRs aforementioned. The OCCRs can be used with the tool provided as by-product of our work which is available at `https://pros.unicam.it/theoc/`. In addition to OCCRs, we outline also the needed formulas, informally presented, to calculate compliance metrics.

$OCCR1 = (P_A^{CR1}, FP_b, \psi^{CR1}, \delta^{CR1}, P_B^{CR1})$, where:
P_A^{CR1} = (Register Customer Order, *true*, =, 1, registered CO, Customer Order, *true*)
FP_b = exclusive
ψ^{CR1} = [TD for CO, CR for TD]
$\delta^{CR1} = (>, 0)$
P_B^{CR1} = (Drive to Terminal, *true*, =, 1, CR moved, Container, *true*)

In addition to $OCCR1$, we need a function grouping the events in M by "Customer" object, this would return a series of subsets of M, and each subset would reflect the events of a single "Customer" object; secondly, we have to use a function to count the cardinality of such subsets. Whenever a count results in more than 5, the respective customer violated the compliance rule on the maximum of orders created.

$OCCR2 = (P_A^{CR2}, FP_b, \psi^{CR2}, \delta^{CR2}, P_B^{CR2})$, where:
P_A^{CR2} = (Register Customer Order, *true*, =, 1, registered CO, Customer Order, *true*)
FP_b = xLeadsTo
ψ^{CR2} = [TD for CO]
$\delta^{CR2} = (>, 0)$
P_B^{CR2} = (Create Transport Document, *true*, =, 1, created TD, Transport Document, *true*)

In $OCCR2$, any couple of events in NM is considered a violation, since it means that the handling of an order has started without a proper transport document created.

$OCCR3 = (P_A^{CR3}, FP_b, \psi^{CR3}, \delta^{CR3}, P_B^{CR3})$, where:
P_A^{CR3} = (Book vehicle, *true*, =, 1, VHS booked for TD, Transport Document, *true*)
FP_b = corequisite
ψ^{CR3} = [CR for TD, TR loads CR]
$\delta^{CR3} = (<, 172800)$
P_B^{CR3} = (Drive to terminal, *true*, =, 1, TR moved, Truck, *true*)

In the case of $OCCR3$, couples of events in NM represents the orders handled exceeding the specified time.

$OCCR4 = (P^{CR4}, FP_u)$, where:
P^{CR4} = (Reschedule Container, $date\_diff(today(), timestamp) < 7\ days$, =, 1, Rescheduled CO, Container, *true*)
FP_u = occurs

For $OCCR4$, we have to use a function to count directly the cardinality of the entire M set that results from the application of the rule. In that case, the requirement is violated if the count results in more than 10 events.

$$
\begin{aligned}
OCCR5 &= (P_A^{CR5}, FP_b, \psi^{CR5}, \delta^{CR5}, P_B^{CR5}), \qquad \text{where:}\\
P_A^{CR5} &= (\text{CONFIRM ORDER}, \mathit{date\_diff}(\mathit{today}(), \mathit{timestamp}) > 2\ \mathit{days},\\
&\quad =, 1, \text{CUSTOMER}, \text{CUSTOMERS}, \mathit{true})\\
FP_b &= \text{xLeadsTo}\\
\psi^{CR5} &= [\text{places}]\\
\delta^{CR5} &= (\leq, 216000)\\
P_B^{CR5} &= (\text{PAYMENT REMAINDER}, \mathit{true}, =, 1, \text{ORDER}, \text{ORDERS}, \mathit{true})
\end{aligned}
$$

Regarding $OCCR5$, assuming 12 hours for the system to react for a missing payment, the M set corresponds to compliant cases. Differently, in NM, we can observe late remainders, which corresponds to the $E_\psi^{out\delta}$ set.

$$
\begin{aligned}
OCCR6 &= (P^{CR6}, FP_u), \qquad \text{where:}\\
P^{CR6} &= (\text{CONFIRM ORDER}, \mathit{true}, =, 1, \text{SALES PERSON}, \text{EMPLOYEES}, \mathit{role} \neq \text{“}\mathit{Sales}''\text{)}\\
FP_u &= \text{occurs}
\end{aligned}
$$

In $OCCR6$, any event in the M set represent a violation of customers' data privacy preservation.

$$
\begin{aligned}
OCCR7 &= (P_A^{CR7}, FP_b, \psi^{CR7}, \delta^{CR7}, P_B^{CR7}), \qquad \text{where:}\\
P_A^{CR7} &= (\text{CREATE PURCHASE ORDER}, \mathit{true}, =, 1, \text{QUOTATION},\\
&\quad \text{QUOTATION}, \mathit{true})\\
FP_b &= \text{xLeadsTo}\\
\psi^{CR7} &= [\text{Purchase Order of Quotation}]\\
\delta^{CR7} &= (>, 0)\\
P_B^{CR7} &= (\text{APPROVE PURCHASE ORDER}, \mathit{true}, =, 1, \text{PURCHASE ORDER},\\
&\quad \text{PURCHASE ORDER}, \mathit{true})
\end{aligned}
$$

For what concerns $OCCR7$, any couple of events in NM represents a violation, because the approval is mandatory before performing any other activity.

$$
\begin{aligned}
OCCR8 &= (P_A^{CR8}, FP_b, \psi^{CR8}, \delta^{CR8}, P_B^{CR8}), \qquad \text{where:}\\
P_A^{CR8} &= (\text{CREATE INVOICE RECEIPT}, \mathit{true}, =, 1, \text{INVOICE RECEIPT},\\
&\quad \text{INVOICE RECEIPT}, \mathit{true})\\
FP_b &= \text{precedes}\\
\psi^{CR8} &= [\text{invoice\_receipt\_pm}]\\
\delta^{CR8} &= (>, 0)\\
P_B^{CR8} &= (\text{EXECUTE PAYMENT}, \mathit{true}, =, 1, \text{PAYMENT}, \text{PAYMENT}, \mathit{true})
\end{aligned}
$$

In addition to $OCCR8$ we need a grouping function in the M set on the object 'invoice receipt", whenever a subset presents more than one couple of events, it means that a double payment has been executed for the same invoice.

$$
\begin{aligned}
OCCR9 &= (P_A^{CR9}, FP_b, \psi^{CR9}, \delta^{CR9}, P_B^{CR9}), && \text{where:}\\
P_A^{CR9} &= (\textsc{Create Purchase Requisition}, \mathit{datediff}(\mathit{today}(), \mathit{timestamp}) > 2\ \mathit{days},\\
&\quad =, 1, \textsc{purchase\_requisition}, \textsc{purchase\_requisition}, \mathit{true})\\
FP_b &= \text{precedes}\\
\psi^{CR9} &= [\text{assigned\_materials of PR}]\\
\delta^{CR9} &= (>, 172800)\\
P_B^{CR9} &= (\textsc{Approve Purchase Requisition}, \mathit{true}, \geq, 1, \textsc{material},\\
&\quad \textsc{material}, \mathit{true})
\end{aligned}
$$

Lastly, for $OCCR9$ the lengthy cases are those observable in the M set.

References

1. Knopp, B., van der Aalst, W.M.P.: Order management object-centric event log (2023). https://doi.org/https://doi.org/10.5281/zenodo.8428112
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3. Park, G., Tacke, L.: Procure-to-payment (p2p) object-centric event log (2023). https://doi.org/https://doi.org/10.5281/zenodo.8412920