Cerberus: Automated Synthesis of Enforcement Mechanisms for Security-sensitive Business Processes

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SECENTIS

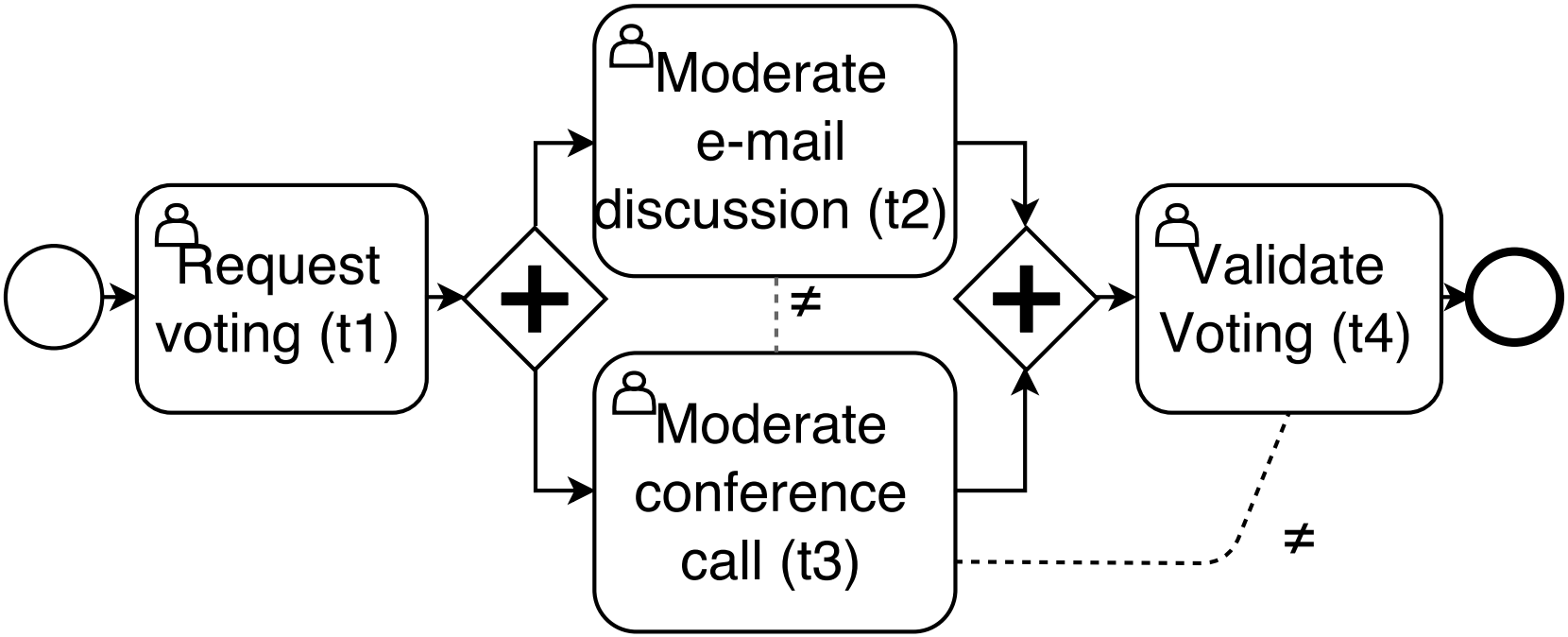
A European Industrial Doctorate on Security and Trust

Outline

Context

- A security-sensitive business process is a structured collection of tasks with:
  - Authorization policy: which users are entitled to execute which tasks
  - Authorization constraints: e.g., some tasks must be performed by the same/different users
- Policy and constraints are crucial to comply with regulations and prevent frauds, but business continuity must not be endangered:
  - It must be possible to complete the process while satisfying the policy and constraints.

Example



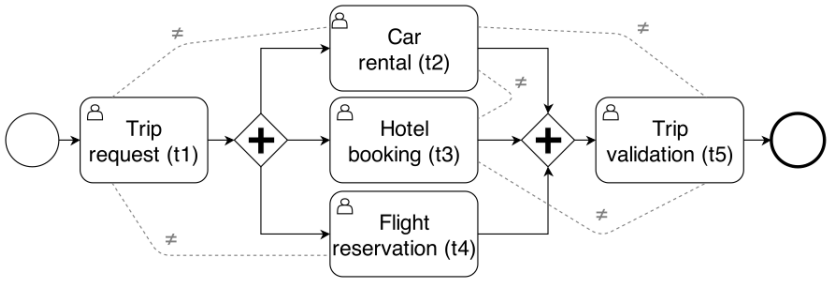
Authorization policy	
t1	A, B, C
t2	A, B, C
t3	A, B
t4	A

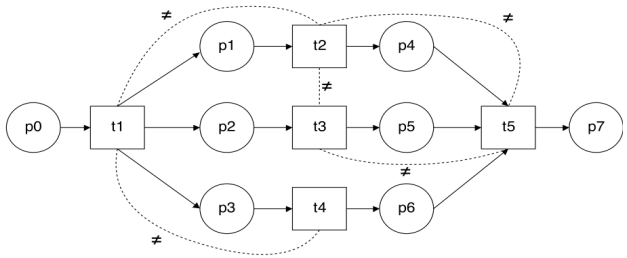
Satisfying runs: t1(C),t2(A),t3(B),t4(A) or
t1(A), t3(B), t2(C), t4(A)

Avoid: t1(A), t2(B), ...

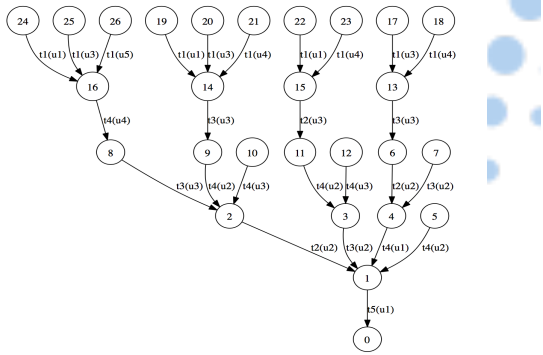
Solution

- Cerberus synthesizes, at design-time, monitors capable of answering, at run-time, user requests to execute tasks
  - request is granted if user is authorized (policy), no constraint is violated and the execution can still terminate (there are users who can perform the next tasks)
- Synthesized monitors are parametric in the authorization policy
  - can be combined at run-time with authorization policies dedicated to different instances of the process.





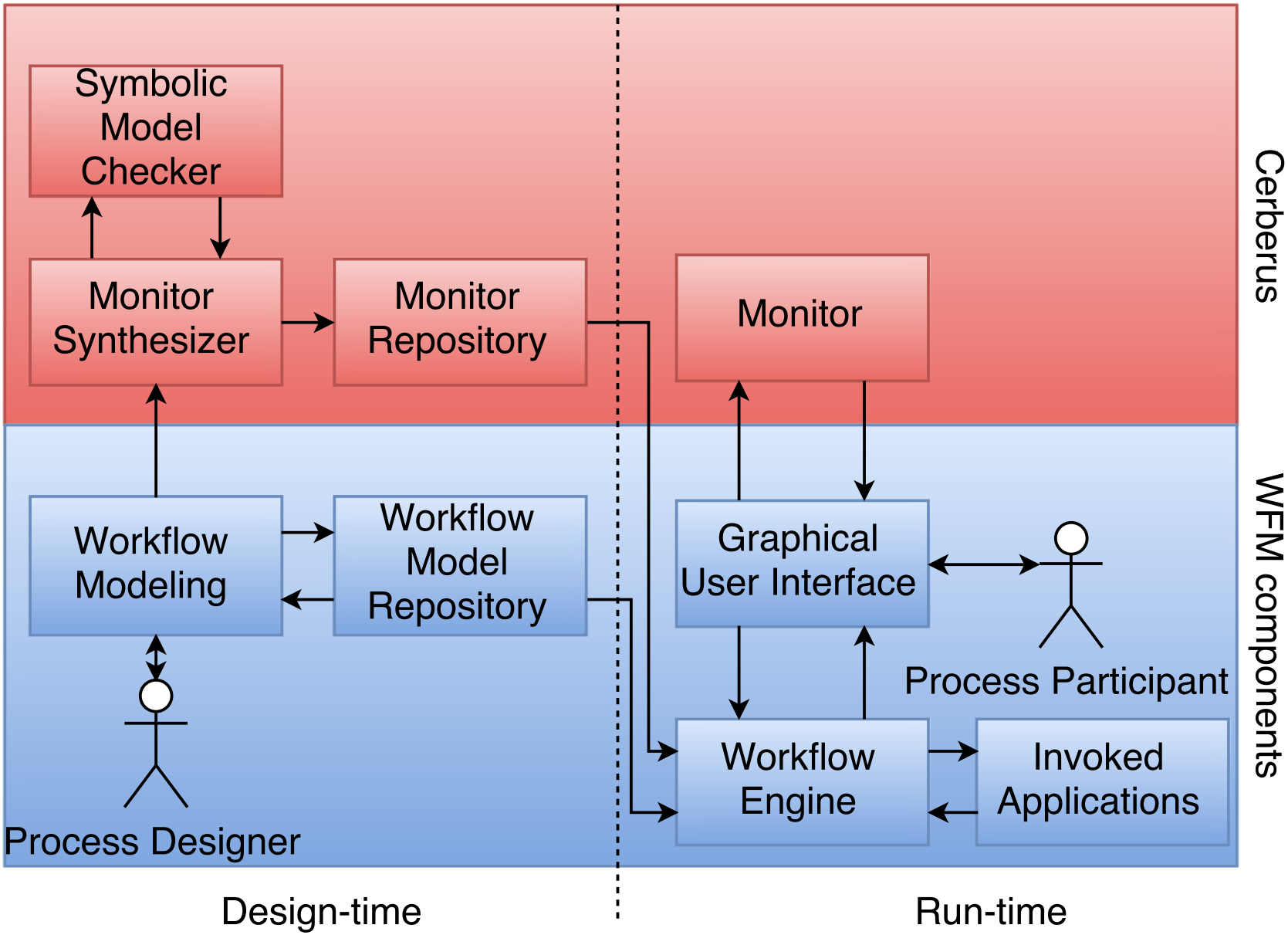
event	enabled		action	
	CF	Auth	CF	Auth
$t1(u)$	$p0 \wedge \neg d_{t1}$	$a_{t1}(u)$	$p0, p1, p2, p3, d_{t1} := F, T, T, T, T$	$h_{t1}(u) := T$
$t2(u)$	$p1 \wedge \neg d_{t2}$	$a_{t2}(u) \wedge \neg\, h_{t3}(u) \wedge \neg\, h_{t1}(u)$	$p1, p4, d_{t2} := F, T, T$	$h_{t2}(u) := T$
$t3(u)$	$p2 \wedge \neg d_{t3}$	$a_{t3}(u) \wedge \neg h_{t2}(u)$	$p2, p5, d_{t3} := F, T, T$	$h_{t3}(u) := T$
$t4(u)$	$p3 \wedge \neg d_{t4}$	$a_{t4}(u) \wedge \neg h_{t1}(u)$	$p3, p6, d_{t4} := F, T, T$	$h_{t4}(u) := T$
$t5(u)$	$p4 \wedge p5 \wedge p6 \wedge \neg d_{t5}$	$a_{t5}(u) \wedge \neg\, h_{t3}(u) \wedge \neg\, h_{t2}(u)$	$p4, p5, p6, p7, d_{t5} := F, F, F, T, T$	$h_{t5}(u) := T$



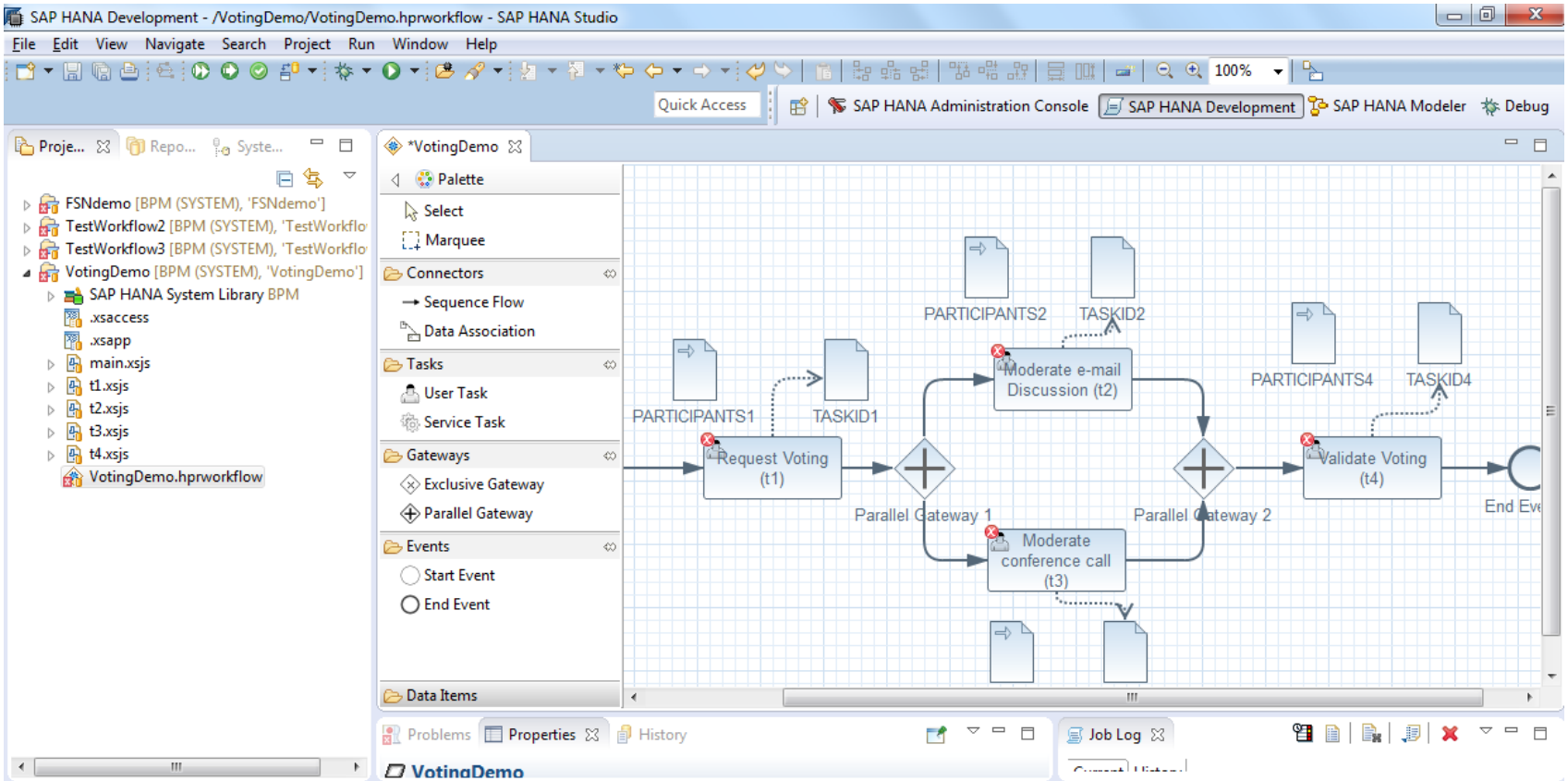
	CF	Auth				*can_do*	
#	Token in	h_{t1}	h_{t2}	h_{t3}	h_{t4}	h_{t5}	(u, t)	Resp.
0	$p0$	-	-	-	-	-	$(a, t1)$	deny
1	$p0$	-	-	-	-	-	$(b, t1)$	grant
2	$p1, p2, p3$	b	-	-	-	-	$(b, t2)$	deny
3	$p1, p2, p3$	b	-	-	-	-	$(a, t2)$	grant
4	$p4, p2, p3$	b	a	-	-	-	$(c, t3)$	grant
5	$p4, p5, p3$	b	a	c	-	-	$(a, t4)$	grant
6	$p4, p5, p6$	b	a	c	a	-	$(b, t5)$	grant
7	$p7$	b	a	c	a	b	-	-

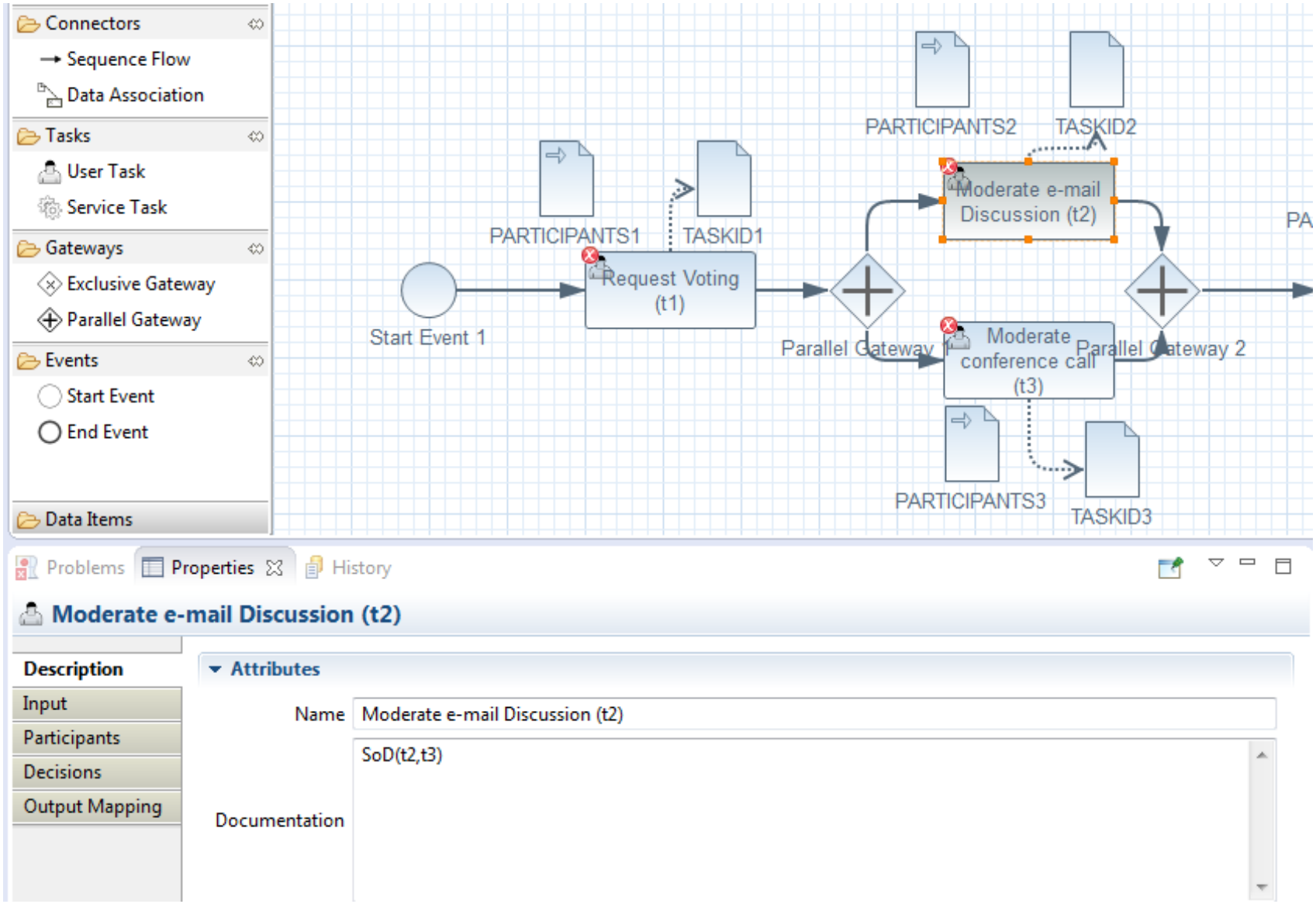
Integration

- Cerberus can be integrated in many workflow management systems
- It is transparent to process designers, and does not require any knowledge beyond usual BP modeling.
- We integrated it into the SAP HANA Operational Intelligence platform, which offers a BPMN modeling and enactment environment.


Symbolic Model Checker
Monitor Synthesizer
Monitor Repository
Monitor
Cerberus
Workflow Modeling
Workflow Model Repository
Graphical User Interface
Process Participant
Workflow Engine
Invoked Applications
Process Designer
WFM components
Design-time
Run-time

Outline


SAP HANA Development - /VotingDemo/VotingDemo.hprworkflow - SAP HANA Studio
File Edit View Navigate Search Project Run Window Help
Quick Access
SAP HANA Administration Console
SAP HANA Development
SAP HANA Modeler
Debug
FSNdemo [BPM (SYSTEM), 'FSNdemo']
TestWorkflow2 [BPM (SYSTEM), 'TestWorkflo
TestWorkflow3 [BPM (SYSTEM), 'TestWorkflo
VotingDemo [BPM (SYSTEM), 'VotingDemo']
SAP HANA System Library BPM
.xsaccess
.xsapp
main.xsjs
t1.xsjs
t2.xsjs
t3.xsjs
t4.xsjs
VotingDemo.hprworkflow
*VotingDemo
Palette
Select
Marquee
Connectors
Sequence Flow
Data Association
Tasks
User Task
Service Task
Gateways
Exclusive Gateway
Parallel Gateway
Events
Start Event
End Event
Data Items
PARTICIPANTS1
TASKID1
PARTICIPANTS2
TASKID2
PARTICIPANTS4
TASKID4
Request Voting (t1)
Moderate e-mail Discussion (t2)
Moderate conference call (t3)
Validate Voting (t4)
Parallel Gateway 1
Parallel Gateway 2
Problems
Properties
History
Job Log
VotingDemo


Connectors
Sequence Flow
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User Task
Service Task
Gateways
Exclusive Gateway
Parallel Gateway
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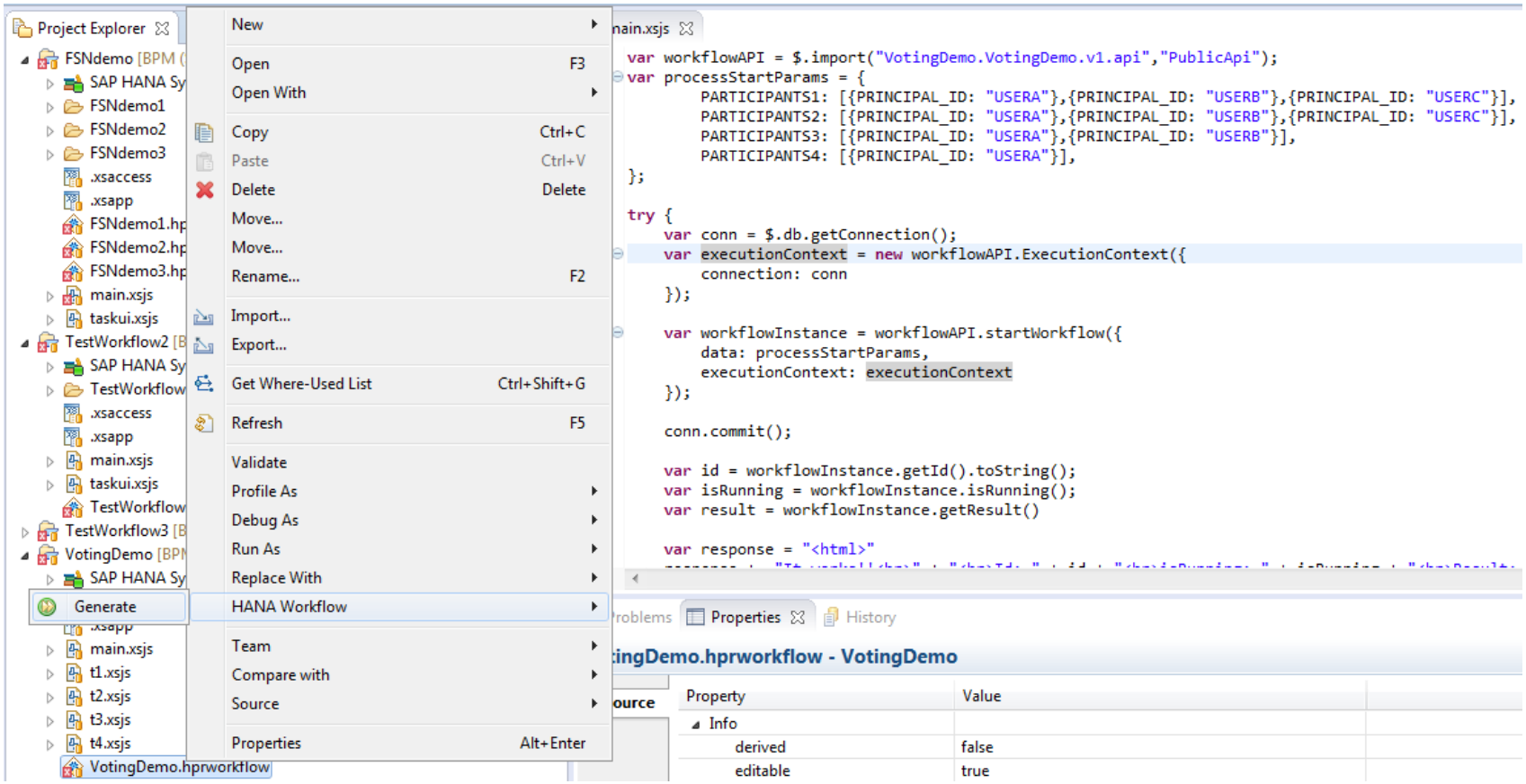
Start Event
End Event
Data Items
PARTICIPANTS1
TASKID1
PARTICIPANTS2
TASKID2
Start Event 1
Request Voting (t1)
Moderate e-mail Discussion (t2)
Parallel Gateway 1
Moderate conference call (t3)
Parallel Gateway 2
PARTICIPANTS3
TASKID3
Problems
Properties
History
Moderate e-mail Discussion (t2)
Description
Input
Participants
Decisions
Output Mapping
Attributes
Name
Moderate e-mail Discussion (t2)
SoD(t2,t3)
Documentation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FSNdemo3
.xsaccess
.xsapp
FSNdemo1.hp
FSNdemo2.hp
FSNdemo3.hp
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taskui.xsjs
TestWorkflow2 [B
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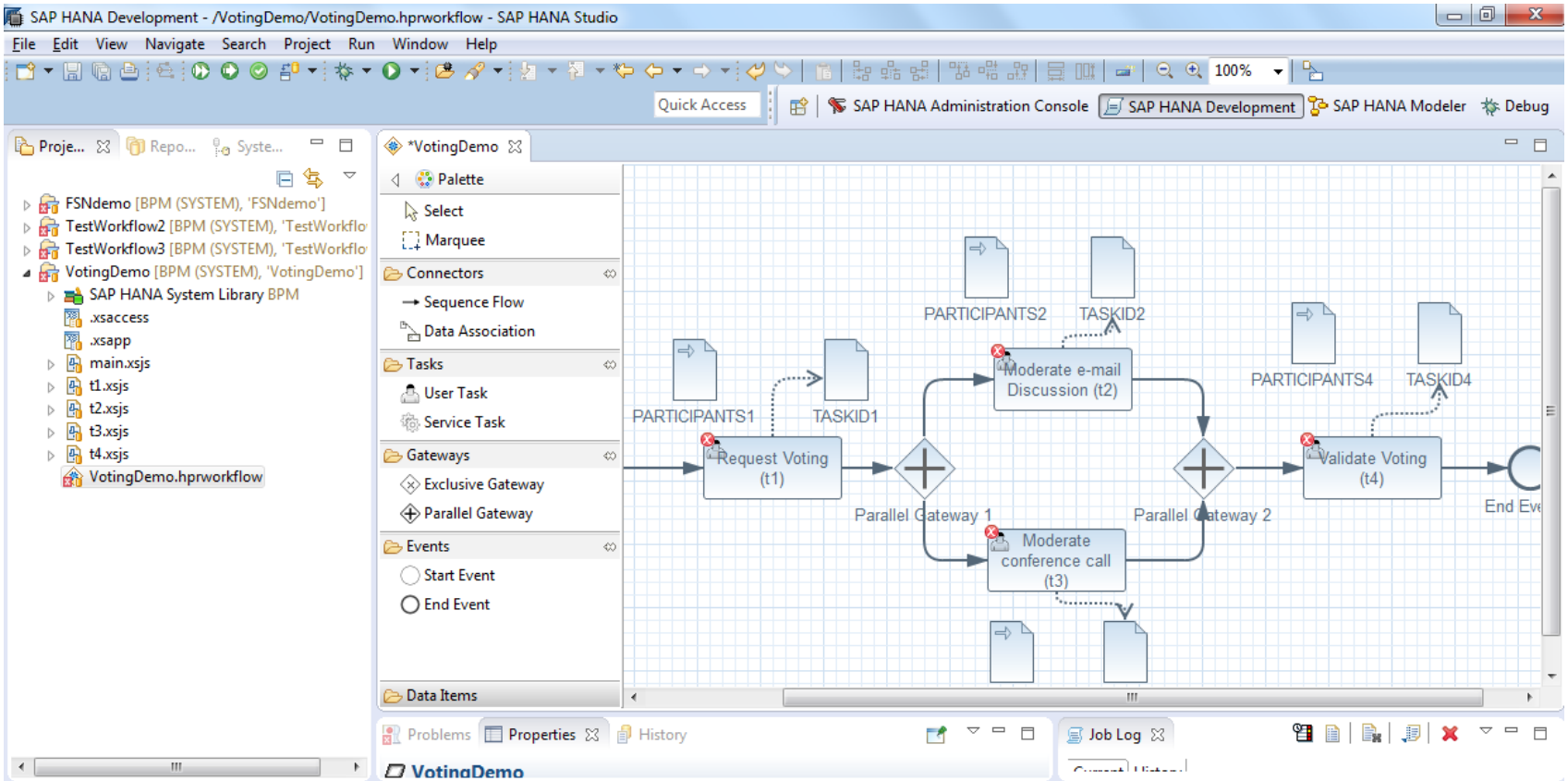
.xsapp
main.xsjs
taskui.xsjs
TestWorkflow
TestWorkflow3 [B
VotingDemo [BPM
SAP HANA Sy
Generate
main.xsjs
t1.xsjs
t2.xsjs
t3.xsjs
t4.xsjs
VotingDemo.hprworkflow
New
Open F3
Open With
Copy Ctrl+C
Paste Ctrl+V
Delete Delete
Move...
Move...
Rename... F2
Import...
Export...
Get Where-Used List Ctrl+Shift+G
Refresh F5
Validate
Profile As
Debug As
Run As
Replace With
HANA Workflow
Team
Compare with
Source
Properties Alt+Enter
nain.xsjs
var workflowAPI = $.import("VotingDemo.VotingDemo.v1.api","PublicApi");
var processStartParams = {
PARTICIPANTS1: [{PRINCIPAL_ID: "USERA"},{PRINCIPAL_ID: "USERB"},{PRINCIPAL_ID: "USERC"}],
PARTICIPANTS2: [{PRINCIPAL_ID: "USERA"},{PRINCIPAL_ID: "USERB"},{PRINCIPAL_ID: "USERC"}],
PARTICIPANTS3: [{PRINCIPAL_ID: "USERA"},{PRINCIPAL_ID: "USERB"}],
PARTICIPANTS4: [{PRINCIPAL_ID: "USERA"}],
};
try {
var conn = $.db.getConnection();
var executionContext = new workflowAPI.ExecutionContext({
connection: conn
});
var workflowInstance = workflowAPI.startWorkflow({
data: processStartParams,
executionContext: executionContext
});
conn.commit();
var id = workflowInstance.getId().toString();
var isRunning = workflowInstance.isRunning();
var result = workflowInstance.getResult()
var response = "<html>"
roblems
Properties
History
tingDemo.hprworkflow - VotingDemo
ource
Property
Value
Info
derived
false
editable
true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TASKID2
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TASKID4
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Moderate conference call (t3)
Validate Voting (t4)
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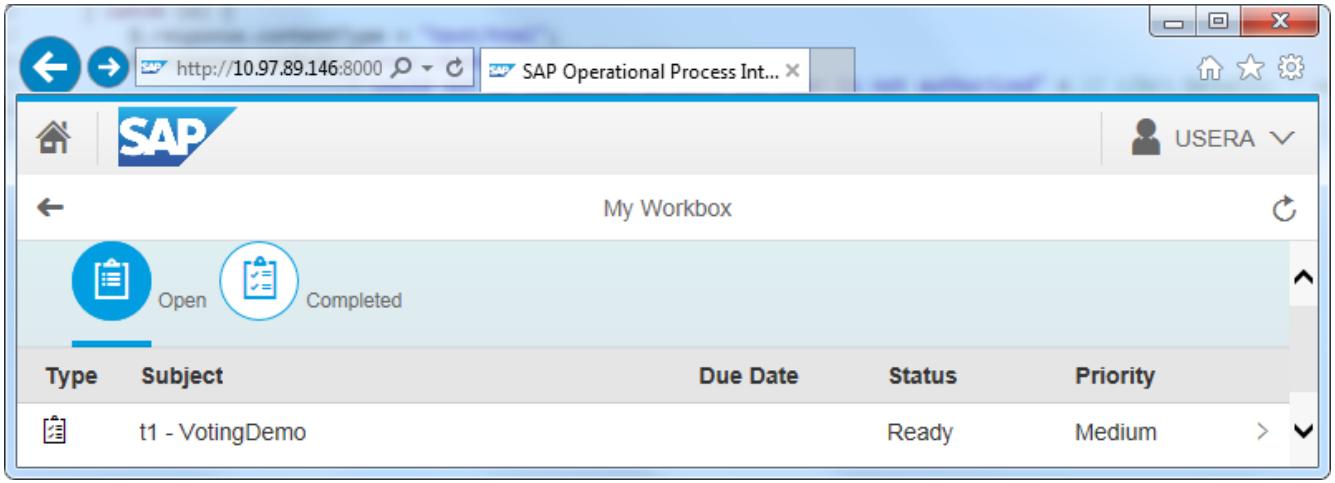
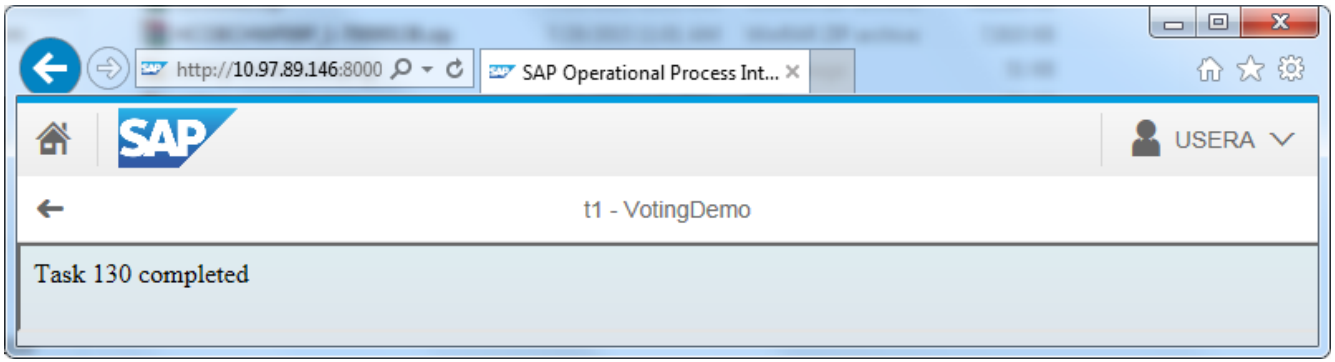
Parallel Gateway 2
Problems
Properties
History
Job Log
VotingDemo

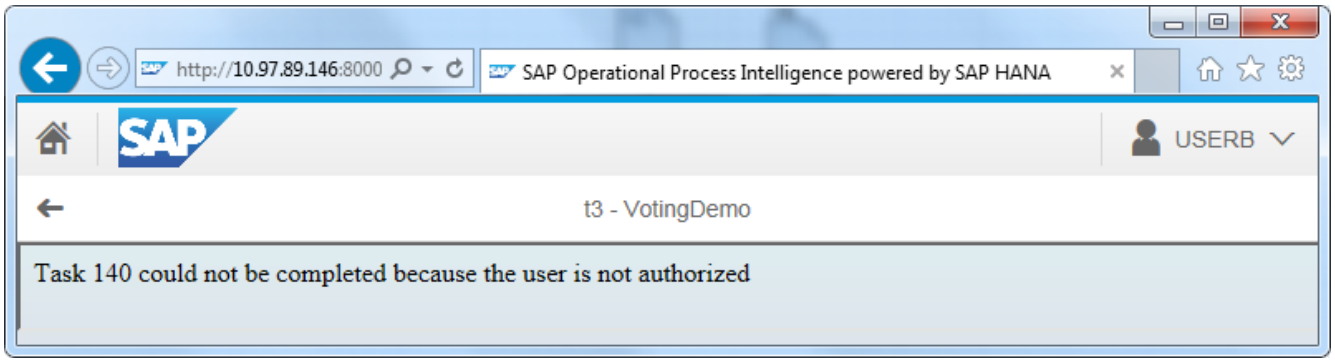
VotingDemo__VotingDemo

Details

```
131
132   --monitor auhtorization check for UserTask_2
133   ELSEIF TASK_ID_IN = m_task_id_UserTask_2 THEN
134     var_out =
135     SELECT
136       CASE WHEN T.STATUS='READY' AND (A.ROLE_TYPE='PARTICIPANT' OR A.ROLE_TYPE='OWNER') THEN 1 ELSE 0 END AS "CAN_COMPLETE",
137       T.TASK_ID
138       FROM "TASKMGT"."sap.bc.taskmgt.task::TASK" AS T INNER JOIN "TASKMGT"."sap.bc.taskmgt.task::ASSIGNMENT" AS A ON T.TASK_ID = A.TASK_ID
139       WHERE (T.CATEGORY = 'TASK' OR T.CATEGORY = 'CHECKLIST')
140       AND A.PRINCIPAL_ID IN
141       (
142       --monitor query
143       SELECT DISTINCT Z1."USER_NAME" FROM "SYS"."USERS" AS Z1 WHERE  doneUserTask_2 = 0 AND doneUserTask_4 = 0 AND doneUserTask_1 = 1 AND d
144       UNION
145       SELECT DISTINCT Z2."USER_NAME" FROM "SYS"."USERS" AS Z1, "SYS"."USERS" AS Z2 WHERE  doneUserTask_2 = 0 AND doneUserTask_4 = 0 AND don
146       UNION
147       SELECT DISTINCT Z1."USER_NAME" FROM "SYS"."USERS" AS Z1, "SYS"."USERS" AS Z2 WHERE  doneUserTask_2 = 0 AND doneUserTask_3 = 0 AND don
148       UNION
149       SELECT DISTINCT Z3."USER_NAME" FROM "SYS"."USERS" AS Z1, "SYS"."USERS" AS Z2, "SYS"."USERS" AS Z3 WHERE  doneUserTask_2 = 0 AND doneU
150       UNION
151       SELECT DISTINCT Z2."USER_NAME" FROM "SYS"."USERS" AS Z1, "SYS"."USERS" AS Z2 WHERE  doneUserTask_2 = 0 AND doneUserTask_4 = 0 AND don
152       UNION
153       SELECT DISTINCT Z1."USER_NAME" FROM "SYS"."USERS" AS Z1 WHERE  doneUserTask_2 = 0 AND doneUserTask_4 = 0 AND doneUserTask_1 = 1 AND d
154       --end of monitor query
155       ) AND A.PRINCIPAL_ID = SESSION_USER;
156
157   --monitor auhtorization check for UserTask_3
158   ELSEIF TASK_ID_IN = m_task_id_UserTask_3 THEN
159     var_out =
160     SELECT
161       CASE WHEN T.STATUS='READY' AND (A.ROLE_TYPE='PARTICIPANT' OR A.ROLE_TYPE='OWNER') THEN 1 ELSE 0 END AS "CAN_COMPLETE",
162       T.TASK_ID
163       FROM "TASKMGT"."sap.bc.taskmgt.task::TASK" AS T INNER JOIN "TASKMGT"."sap.bc.taskmgt.task::ASSIGNMENT" AS A ON T.TASK_ID = A.TASK_ID
164       WHERE (T.CATEGORY = 'TASK' OR T.CATEGORY = 'CHECKLIST')
165       AND A.PRINCIPAL_ID IN
166       (
167       --monitor query
168       SELECT DISTINCT Z2."USER_NAME" FROM "SYS"."USERS" AS Z1, "SYS"."USERS" AS Z2 WHERE  doneUserTask_3 = 0 AND doneUserTask_4 = 0 AND don
169       UNION
170       SELECT DISTINCT Z2."USER_NAME" FROM "SYS"."USERS" AS Z1, "SYS"."USERS" AS Z2 WHERE  doneUserTask_2 = 0 AND doneUserTask_3 = 0 AND don
171       UNION
172       SELECT DISTINCT Z3."USER_NAME" FROM "SYS"."USERS" AS Z1, "SYS"."USERS" AS Z2, "SYS"."USERS" AS Z3 WHERE  doneUserTask_2 = 0 AND doneU
173       UNION
174       SELECT DISTINCT Z2."USER_NAME" FROM "SYS"."USERS" AS Z1, "SYS"."USERS" AS Z2 WHERE  doneUserTask_2 = 0 AND doneUserTask_3 = 0 AND don
175       --end of monitor query
176       ) AND A.PRINCIPAL_ID = SESSION_USER;
177
178   --monitor auhtorization check for UserTask_4
```


http://10.97.89.146:8000
SAP Operational Process Int...
USERA
My Workbox
Open
Completed
Type
Subject
Due Date
Status
Priority
t1 - VotingDemo
Ready
Medium


http://10.97.89.146:8000
SAP Operational Process Int...
USERA
t1 - VotingDemo
Task 130 completed


http://10.97.89.146:8000
SAP Operational Process Intelligence powered by SAP HANA
USERB
t3 - VotingDemo
Task 140 could not be completed because the user is not authorized

Outline

Conclusion

- We have other papers describing in more details the techniques used in the tool:
  - "Automated Synthesis of Run-time Monitors to Enforce Authorization Policies in Business Processes" in ASIACCS 2015
  - "Assisting the Deployment of Security-Sensitive Workflows by Finding Execution Scenarios" in DBSec 2015
- The tool is under development and there is a pilot project for internal use in SAP (payment approval workflows)
- Not yet available for public use

Thank you!

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