Master Thesis: Discovering Clinical Pathways of an Adaptive Integrated Care Environment

Simon Bönisch, 22.07.2019, Final Presentation

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Outline

Motivation & Goals

- CONNECARE – Adaptive Integrated Care Environment
- SACM – Smart Adaptive Case Management
- Research Goals

Approach & Implementation

- Mitigating the Challenges of Process Mining in Healthcare
- Adapted Methodology for Process Mining in Healthcare
- Implementation using the ELK Stack and Disco

Evaluation

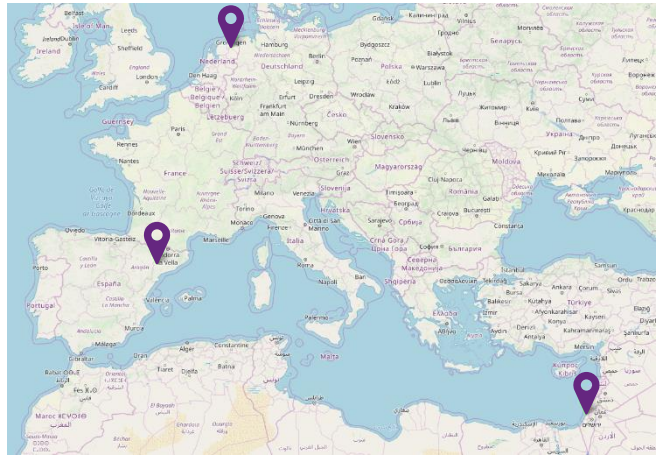
- RQ1 – Model-Provided Flexibility
- RQ2 – Communication and Notification Features
- RQ3 – Collaboration and Organization Features

Conclusion & Future Work

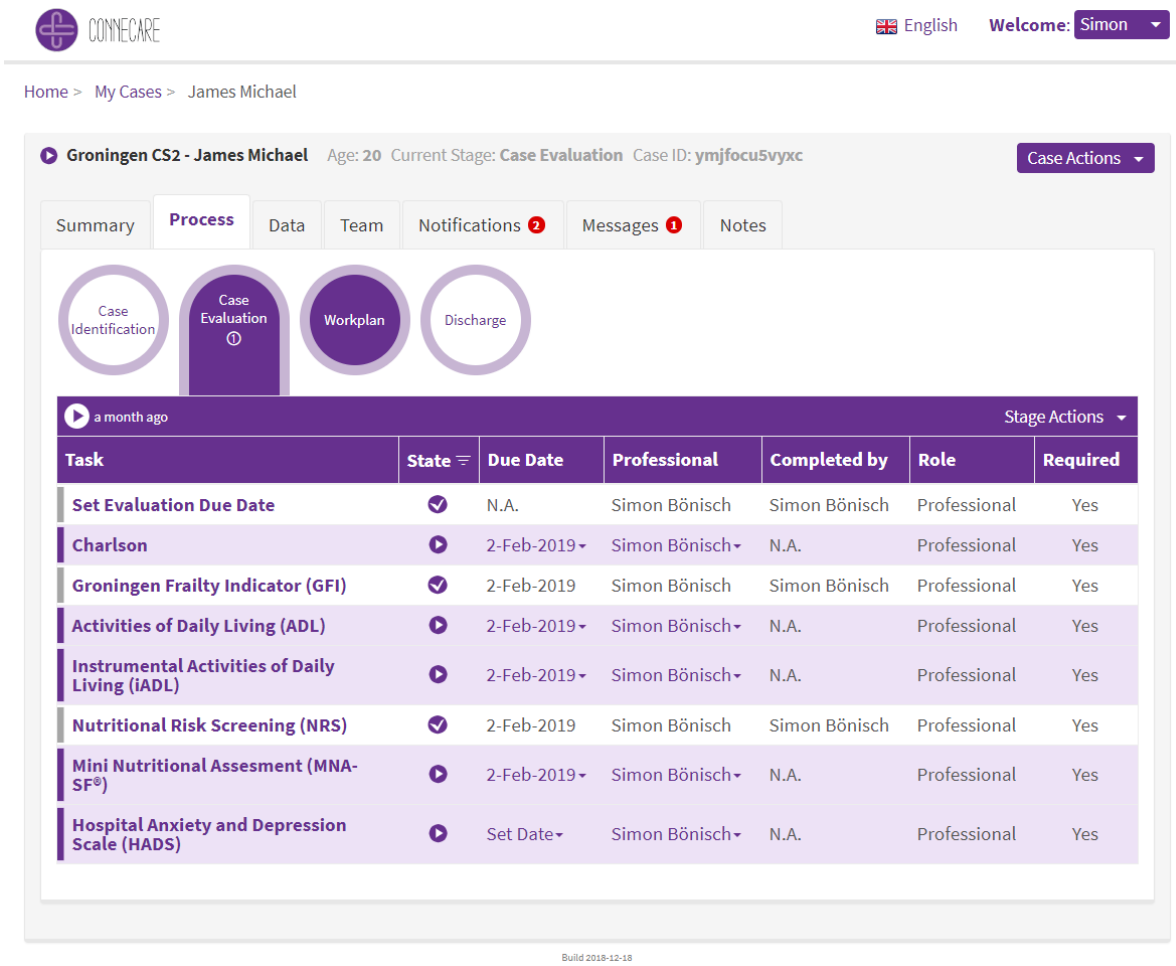
CONNECARE – Adaptive Integrated Care Environment

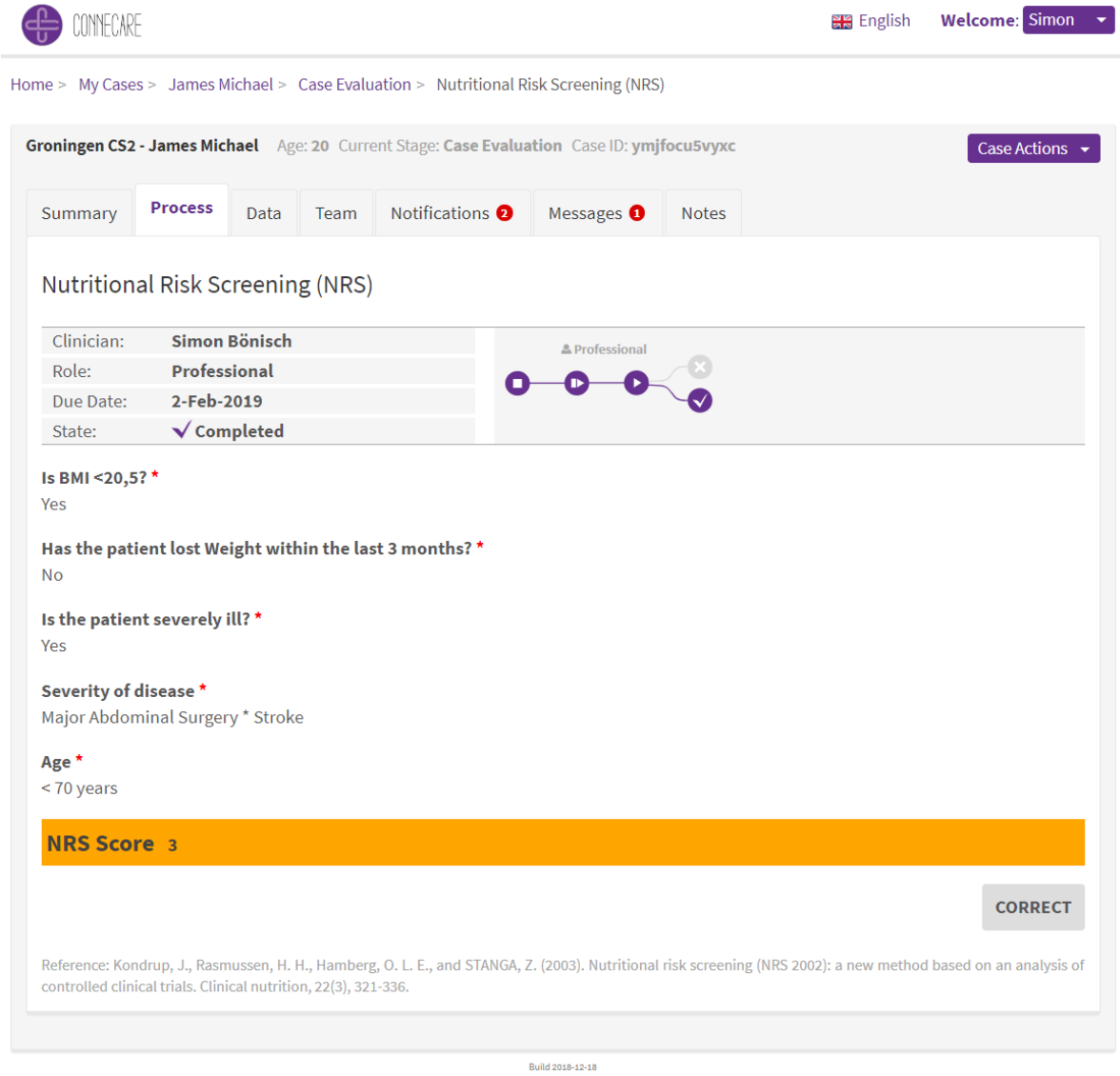
- Aimed at mostly **elderly patients** with **multiple chronic diseases** (Catalonia: make up 5% of population but account for **~36% of costs**)
- CONNECARE integrates **clinical treatment**, **primary care** and **home hospitalization** to **save costs** and **increase quality of life**
  - Self management system for patients **reduces number of hospital visits**
  - **Monitoring** and **alerting** for professionals improves quality of care
  - **Role system** and **messaging** improves interdisciplinary collaboration
- Evaluated at **three sites** with **two case studies** each
  - Studies still running (07/2018 – 12/2019)
  - **Groningen** (Netherlands): 60 patients (25 + 35)
  - **Tel-Aviv** (Israel): 80 patients (51 + 29)
  - **Lleida** (Spain): 70 patients (35 + 35)

CONNECARE



CONNECARE – Medical Case Overview



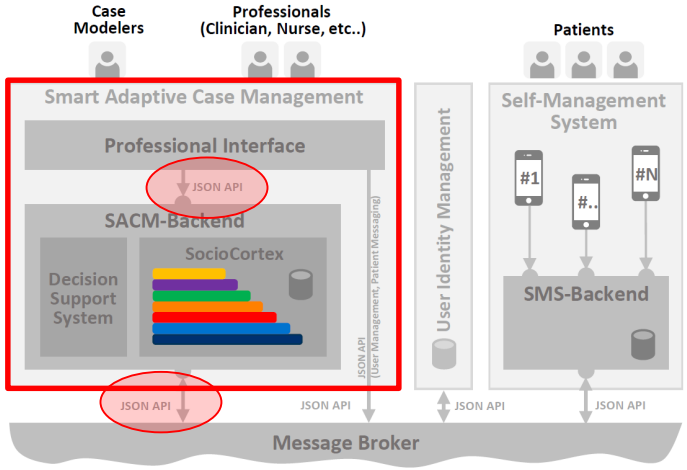


SACM – Smart Adaptive Case Management

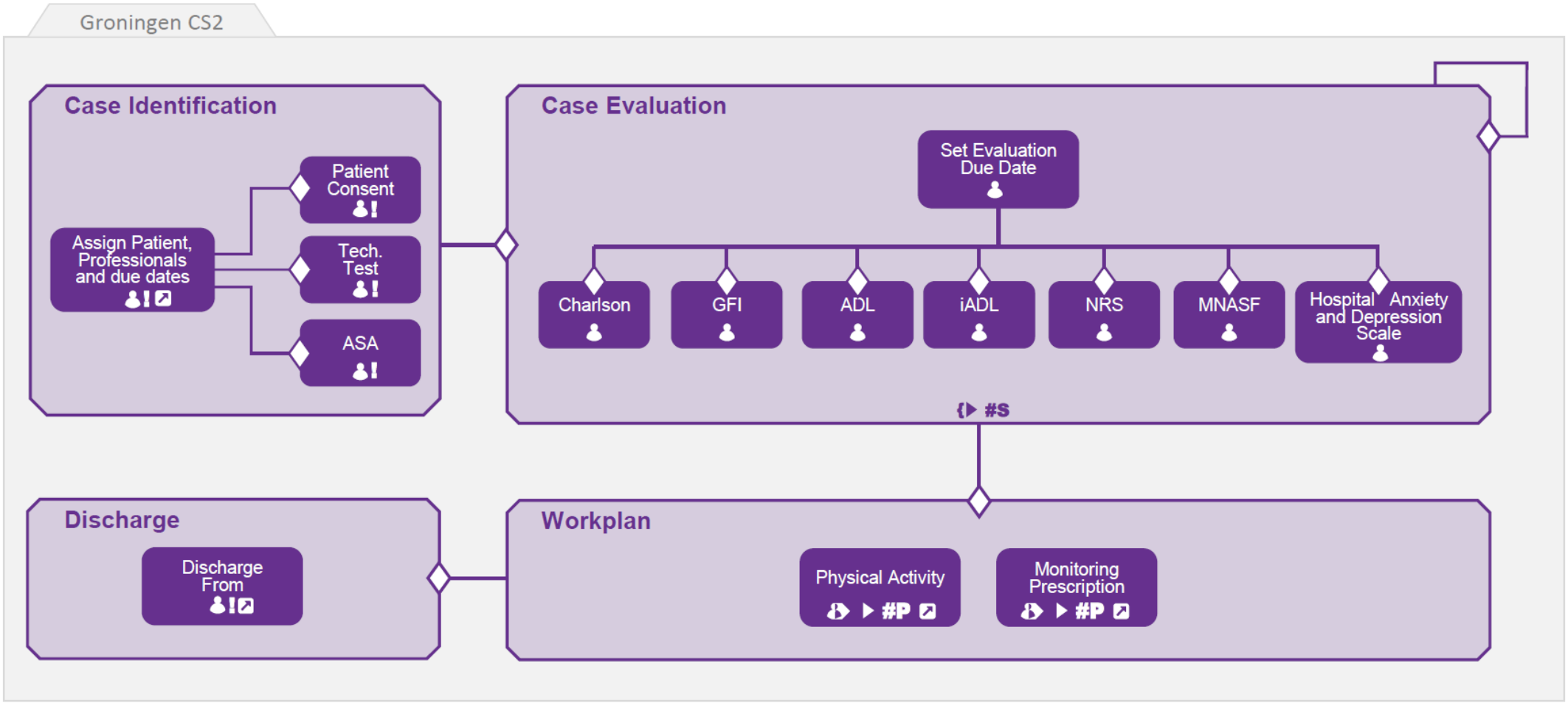
- CONNECARE applies concept of **Clinical Pathways** (CPs) to CCPs
- CPs are **standardized treatment paths** of a typical patient that are **dynamically adapted** when put into practice
- Adaptive Case Management systems (ACMs) typically used to support their execution
- ACMs allow **human decisions** and process **changes at runtime**

CONNECARE

- Support for CPs is implemented by **SACM**, basically a **model-driven process engine**
- Communication via RESTful JSON API
- High degree of **modeling adaptability** due to high diversity of hospital sites and treatments
- High degree of **runtime adaptability** due to Knowledge-intensive Processes
  - Highly dynamic (**unpredictable events & ad-hoc process modifications**)
  - Human knowledge workers make decisions at process runtime
- Needs to be accounted for in case model by using e.g. **optional elements**



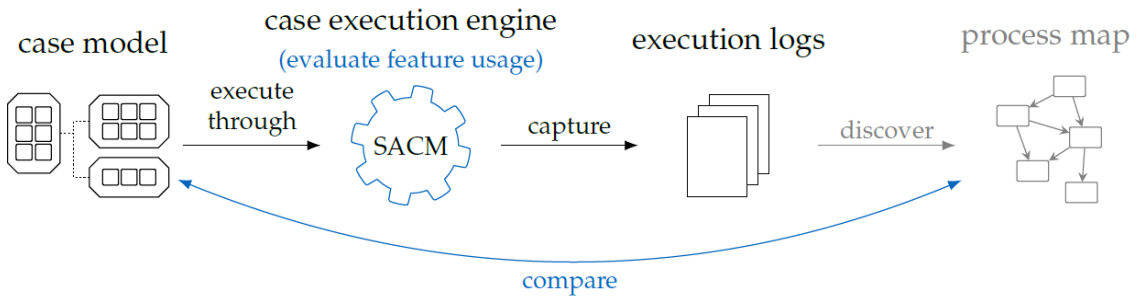
SACM – Case Model in CMMN Notation



Research Goals

- Uncertain if modeled flexibility was actually employed in practice
- Also unsure if additional features of SACM were used and impacted the case executions
- Case model quality is generally important for overall system quality
- Main Questions:
  - How is the model-provided flexibility used during the execution of cases?
  - How do communication and notification features affect case executions?
  - How are collaboration and organization features reflected in case execution logs?

➜ Evaluate actual system usage to **assess** case model quality and feature usage



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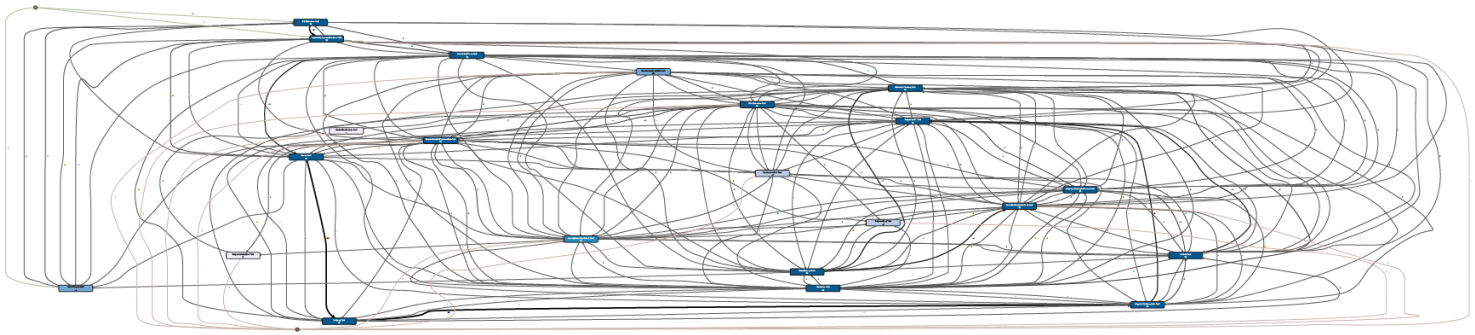
Conclusion & Future Work

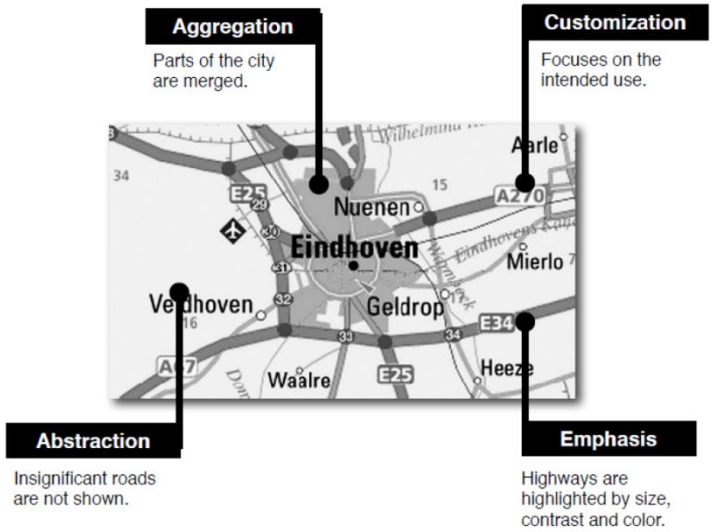
Challenges of Process Mining in Healthcare – The Spaghetti Effect

- Causes
  - **Process/case heterogeneity**
  - Process definition changes
  - **Flexible process execution**
  - Interdisciplinary collaboration



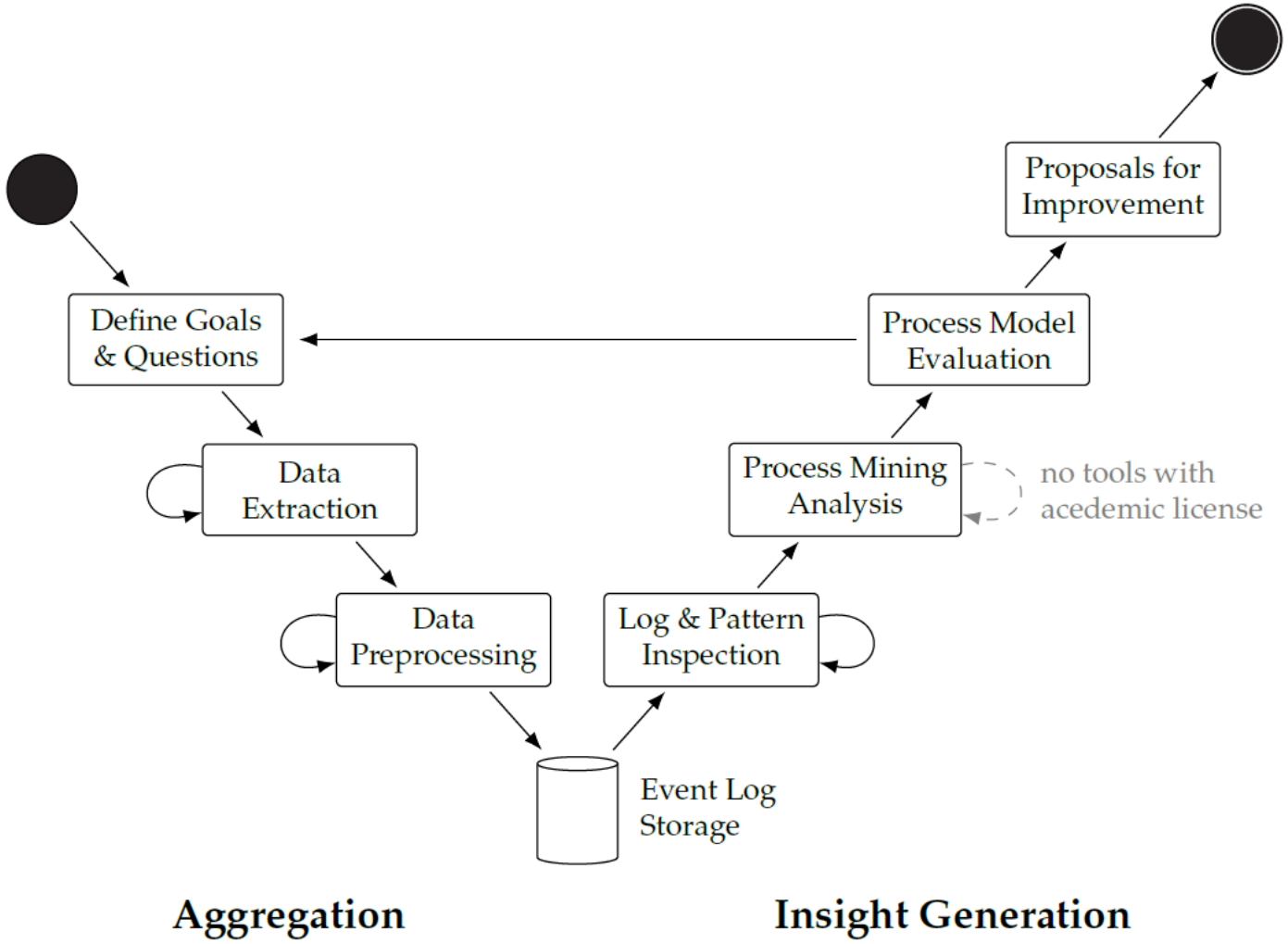
Lleida
without any abstractions

- Mitigations
  - **Fuzzy Mining algorithm**
  - Mapping API access logs onto process events
  - Providing views at **different levels of abstraction**
  - Clustering data
  - Using interactive visualizations
  - Focusing on delta analysis



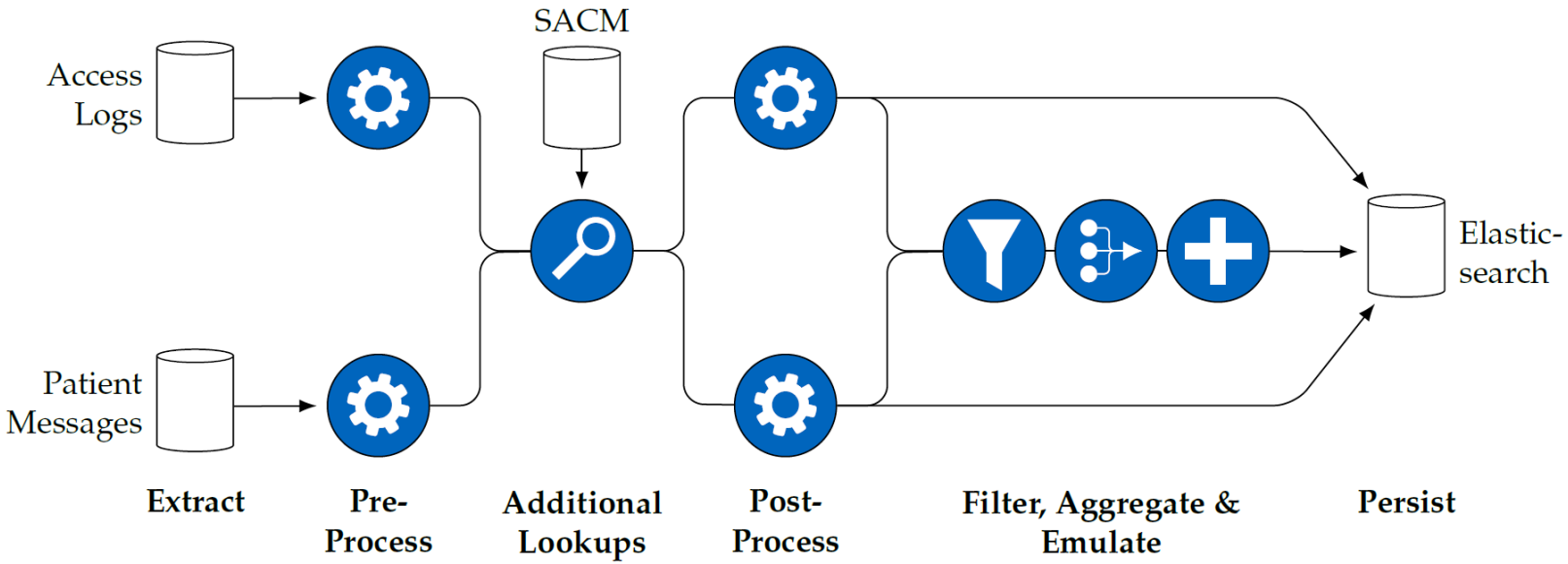
Christian W. Günther. Process mining in flexible environments, 2009.
Fernandez-Llatas et al. Diabetes care related process modelling using Process Mining techniques. Lessons learned in the application of Interactive Pattern Recognition: coping with the Spaghetti Effect.

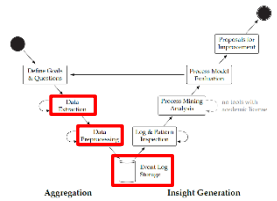
Adapted Methodology for Process Mining in Healthcare



Based on: T. G. Erdogan and A. Tarhan, “A Goal-Driven Evaluation Method Based On Process Mining for Healthcare Processes” in *Appl. Sci. 8*, p. 894, 2018.

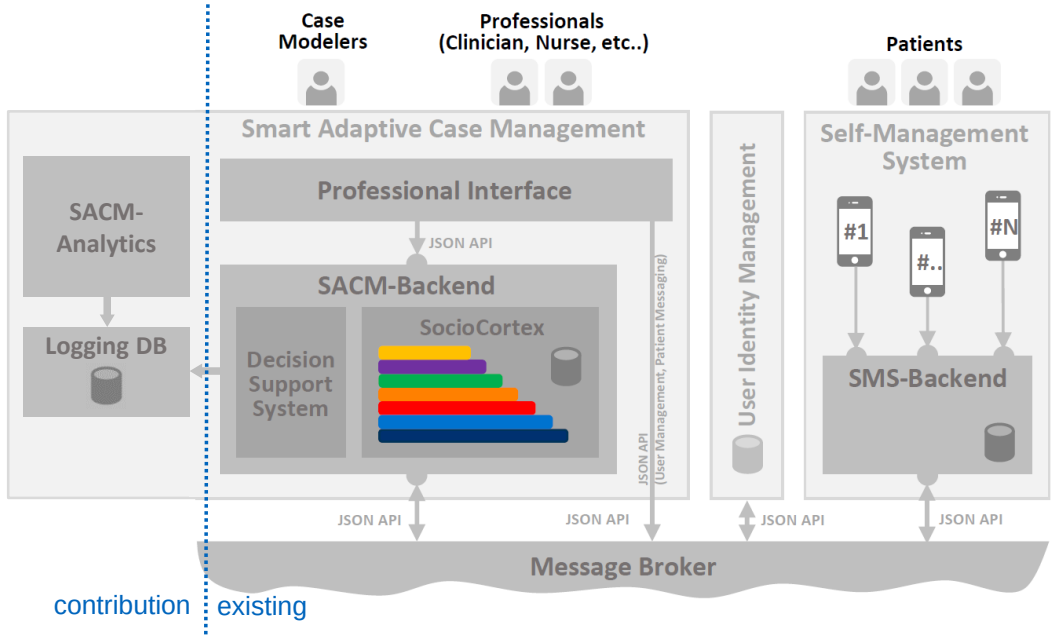
Implementation – Data Extraction & Preprocessing Pipeline





System Integration

- Connecare deployed in three hospitals and **used with real patients**
- **Data protection rules** prevent copying raw data to local system and make deployment necessary to access and analyze the real data
- **Single docker container** to simplify deployment
- **Early deployments** done to the test and productive environments
- Application publicly accessible but **login-protected** (nginx reverse proxy with HTTP Basic Auth)



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RQ1 – How is the model-provided flexibility used during the execution of cases?

Preliminary Considerations

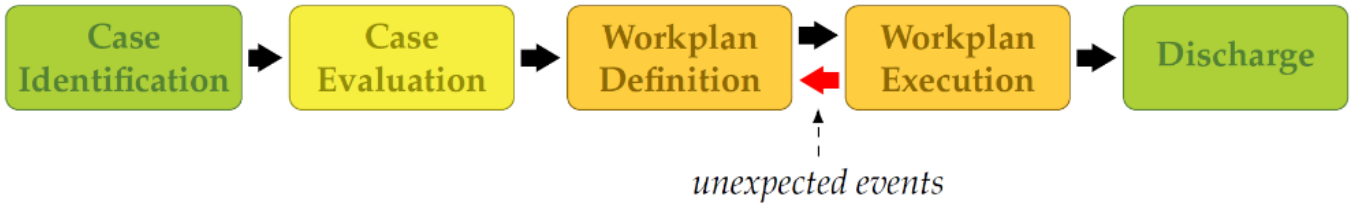
Case model elements **enabling** runtime flexibility:

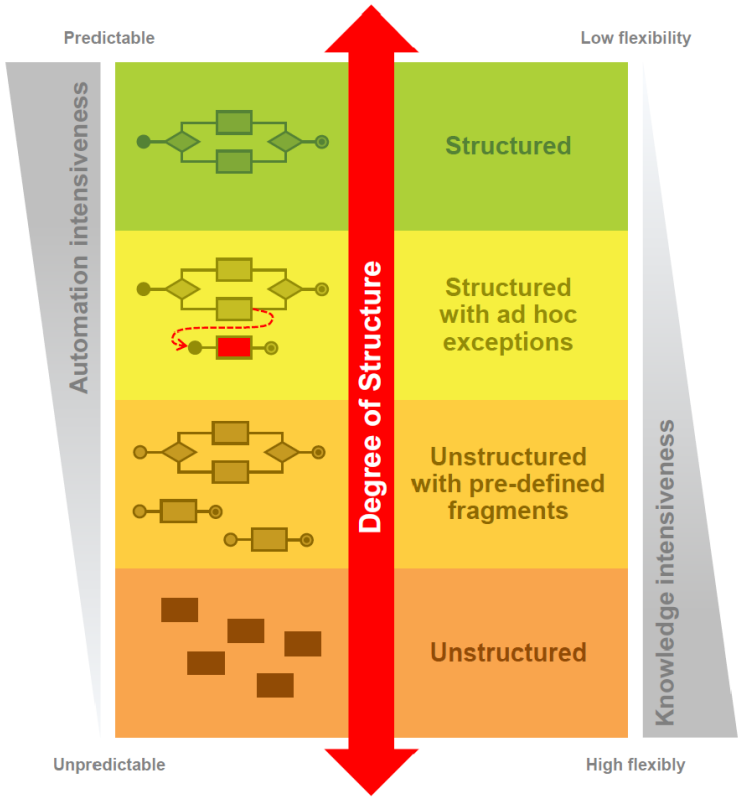
- Optional tasks/stages
- Repeatable tasks/stages (serially/parallel)
- Manually activated tasks/stages

Case model elements **limiting** runtime flexibility:

- Stages
- Sentries on tasks/stages
- Required tasks/stages
- Automated task/stage activations

➜ Determine structuredness based on these elements:
(abstraction across all case models)





C. Di Ciccio, A. Marrella, and A. Russo. Knowledge-Intensive Processes: Characteristics, Requirements and Analysis of Contemporary Approaches. In: Journal on Data Semantics.
I. Cano et al. An adaptive case management system to support integrated care services: Lessons learned from the NEXES project. In: Journal of Biomedical Informatics.

RQ1 – How is the model-provided flexibility used during the execution of cases?

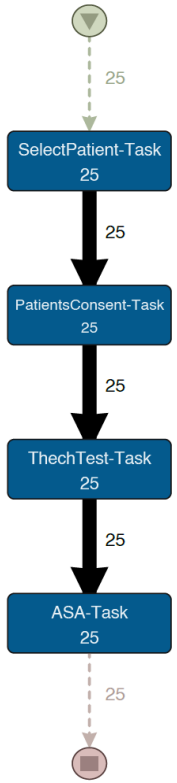
GQFI Evaluation

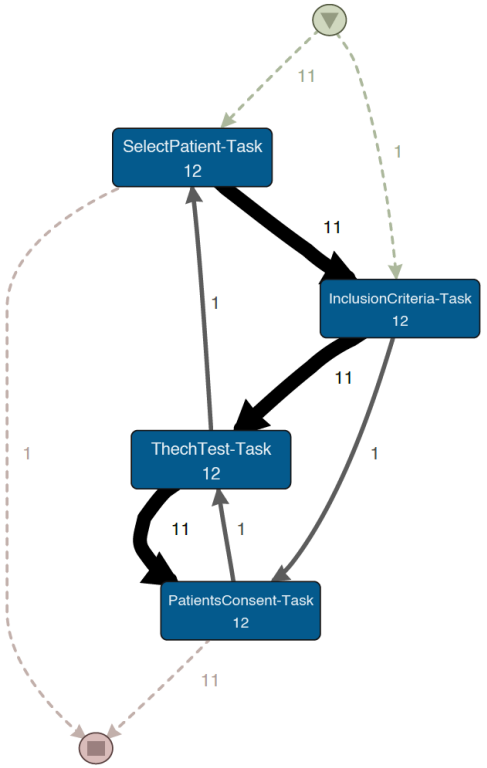
	Case Study 1					Case Study 2				
Indicator	*Identification v7*	*Identification v8*	*Evaluation*	*Workplan*	*Case Level*	*Identification v6*	*Identification v7*	*Evaluation*	*Workplan*	*Case Level*
Number of cases	34	17	47	42	51	12	17	29	29	29
Number of events	153	85	838	1 365	2 976	48	68	680	830	1 967
Number of activities	5	5	18	6	9	4	4	22	6	9
Number of manually activated tasks	0	0	0	1 365	1 365	0	0	0	830	830
Share of manually activated tasks	0%	0%	0%	100%	46%	0%	0%	0%	100%	42%
Number of overall paths	9	4	101	32	40	6	3	114	26	35
Mean number of paths per activity	1.8	0.8	5.6	5.33	4.4	1.5	0.75	5.18	6.5	3.9
Number of bidirectional paths	1	0	14	10	8	1	0	19	9	10
Number of process variants	5	1	34	41	51	2	1	26	28	29
Maximum share of cases per variant	76%	100%	21%	5%	2%	92%	100%	10%	7%	3%
Median case duration	2.8 m	3.7 m	46.4 h	57 d	68.1 d	3.4 m	2.8 m	5.9 d	48.8 d	63.9 d
Mean case duration	44.5 m	2.3 h	7.7 d	48.5 d	62.9 d	10.4 m	3.9 m	14.7 d	55 d	74.4 d
Standard deviation of case duration	3.76 h	5.83 h	17.7 d	34.1 d	41.6 d	13.6 m	3.2 m	24.6 d	45.1 d	49 d

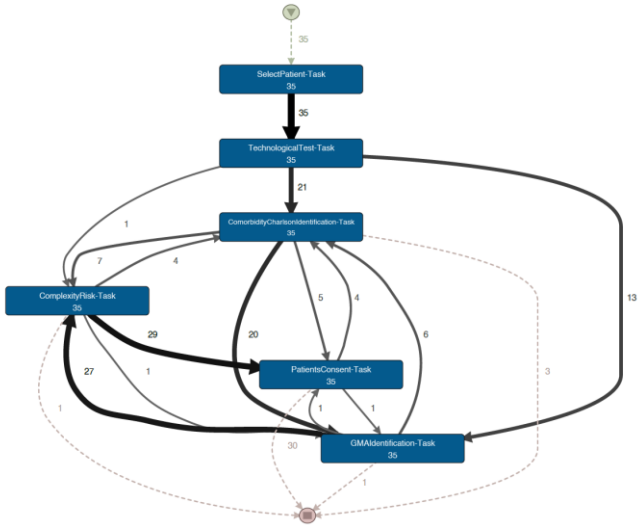
Tel-Aviv

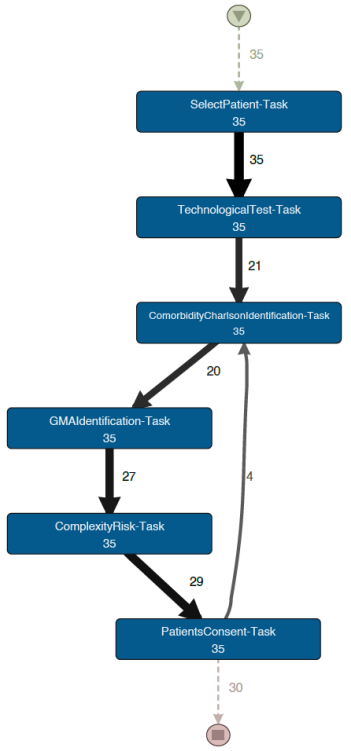
RQ1 – How is the model-provided flexibility used during the execution of cases?

Process Maps – Case Identification Stage









Groningen
actual

Tel-Aviv
actual

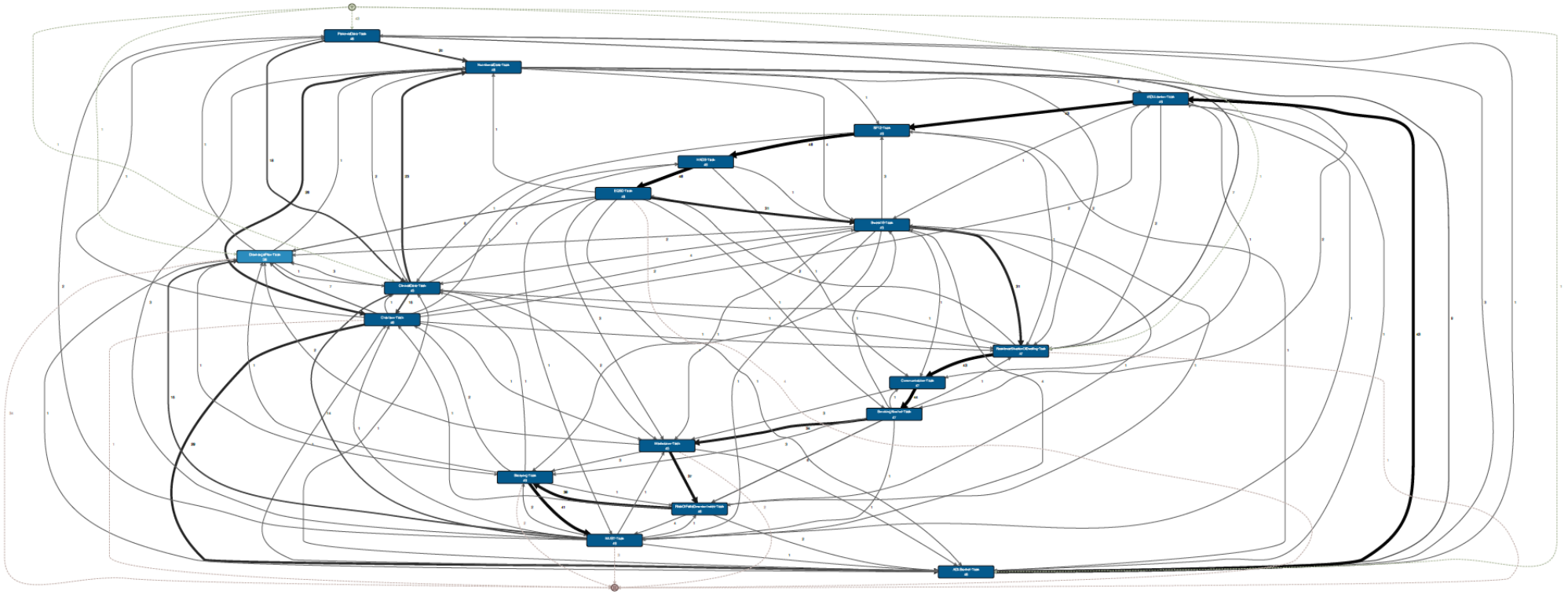
Lleida
actual

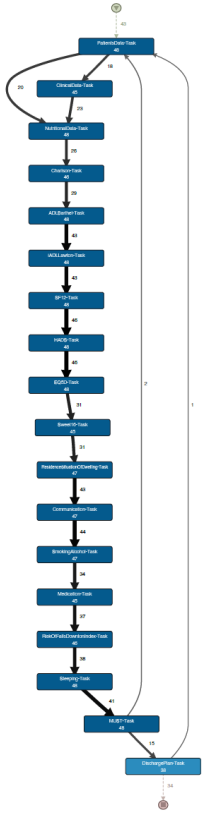
Lleida
abstracted

➜ simple and structured; even all cases executed the same way

RQ1 – How is the model-provided flexibility used during the execution of cases?

Process Maps – Case Evaluation Stage





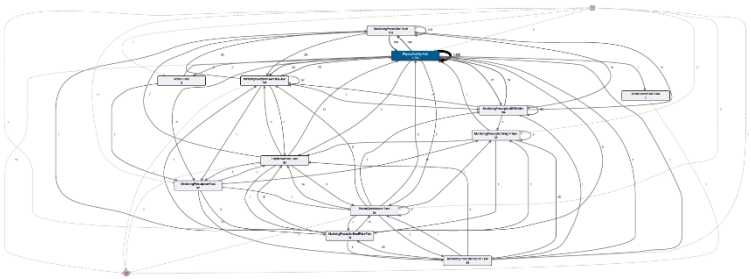
Tel-Aviv
actual

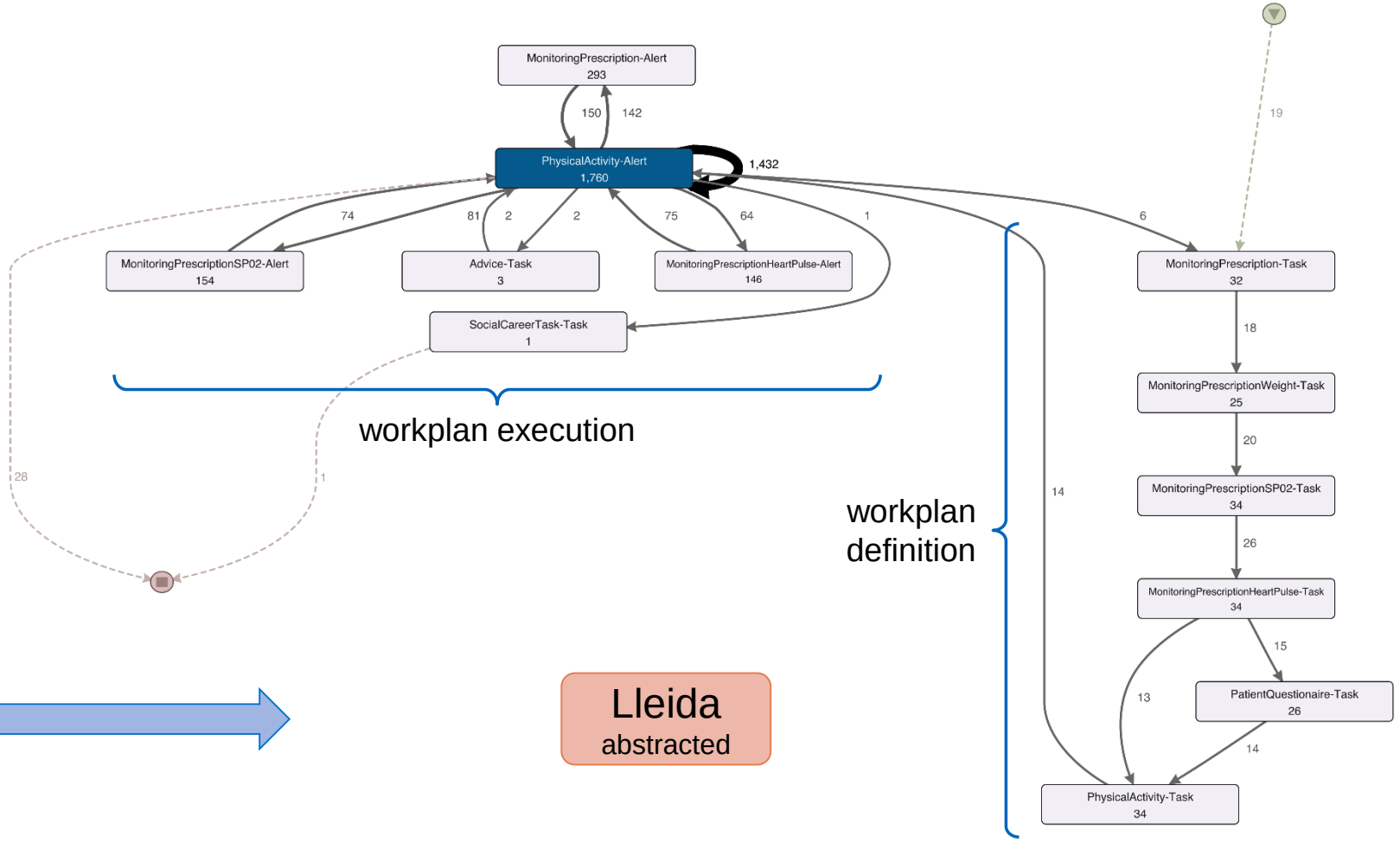
Tel-Aviv
abstracted

➜ complex but not very flexibly used; many cases follow order suggested in web frontend

RQ1 – How is the model-provided flexibility used during the execution of cases?

Process Maps – Workplan Stage





Lleida
actual

Lleida
abstracted

➜ complex and flexibly used; clear division between workplan definition and execution

RQ1 – How is the model-provided flexibility used during the execution of cases?

Conclusion

➜ **Employed where necessary**, otherwise professionals followed **suggestions of web frontend**

➜ Observed structuredness of stages very similar to modeled structuredness

➜ Flexibility does not equal complexity

➜ Observed flexibility **increases with increasing overall activity**

RQ2 – How do communication and notification features affect case executions?

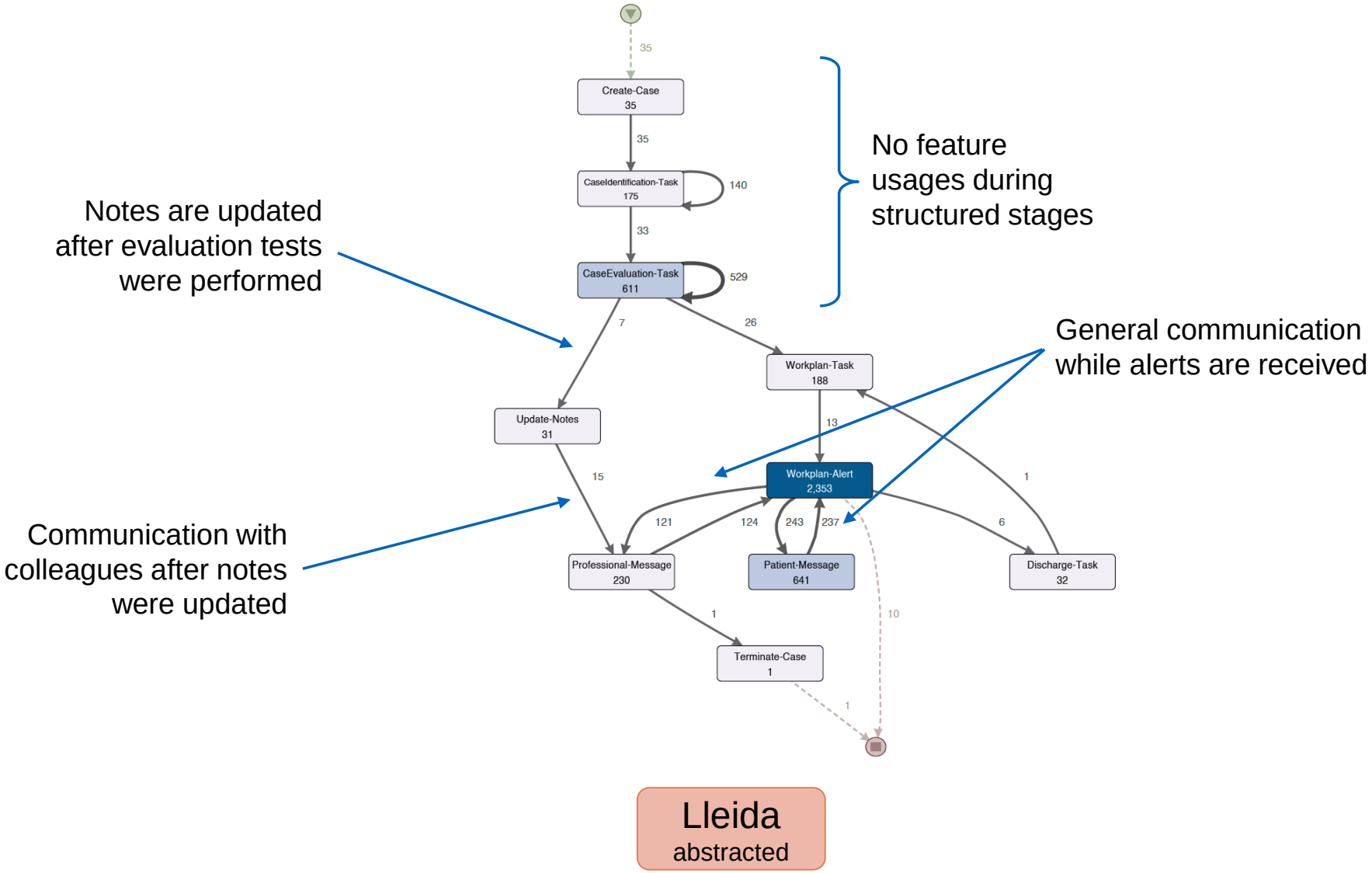
Preliminary Considerations & GQFI Evaluation

- SACM offers features for communication and notification
- **Always available**, independent of the underlying case model
- Three types of features:
  - **Task Alerts:** signalize unexpected conditions during automated measurements
  - **Case Notes:** store additional, unstructured information regarding a case
  - **Messages:** contain general information and questions from colleagues or patients
- Features only used in unforeseen situations
  ➜ can be treated as **unstructured process activities**

	Groningen		Tel-Aviv		Lleida	
Indicator	**CS1**	**CS2**	**CS1**	**CS2**	**CS1**	**CS2**
Number of notes update events	0	0	2	2	31	29
Number of alert events	28	1 192	1 181	649	2 353	1 764
Number of message events (with patients)	57	6	342	201	641	523
Number of message events (with professionals)	0	0	106	97	230	106
Share of feature-related events	37%	79%	55%	48%	76%	69%
Mean number of paths per alert activity	3	2	6	6	7	7
Mean number of paths per message activity	2	3	6.5	6	7.5	8
Mean number of paths per other activity	2	2.25	3.2	3	4.4	5.14

RQ2 – How do communication and notification features affect case executions?

Process Map: Case View



Lleida
abstracted

RQ2 – How do communication and notification features affect case executions?

Conclusion

➜ Features typically used at **later stages of a case**

➜ Heavy **differences from site to site** regarding feature usage

➜ Notes often updated during evaluation stage

➜ Patient messages often received during workplan stage

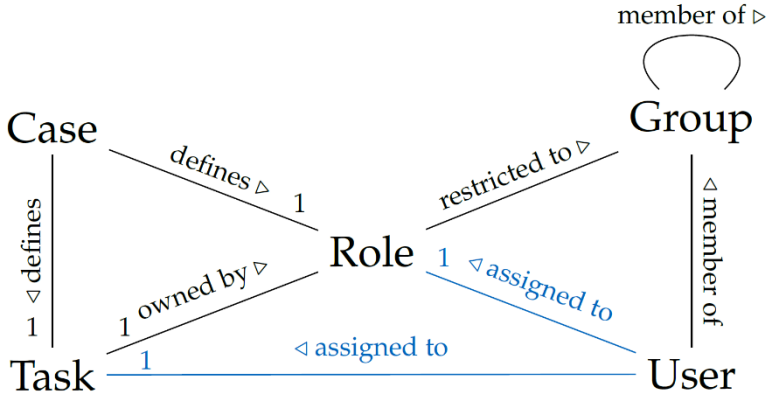
➜ Tel-Aviv used professional messages as replacement for the unknown notes functionality

RQ3 – How are collaboration and organization features reflected in case execution logs?

Preliminary Considerations & GQFI Evaluation

- SACM offers a flexible user and role management system
  - Case **model defines tasks and roles** responsible for each task
  - Roles are restricted to certain groups
  - Users are members of the groups
  - **At runtime**, each role is assigned to a user from one of the groups
- Therefore, tasks are **assigned to a responsible user** (task assignee)
- But tasks **can be done by any user** with case write access (task processor)

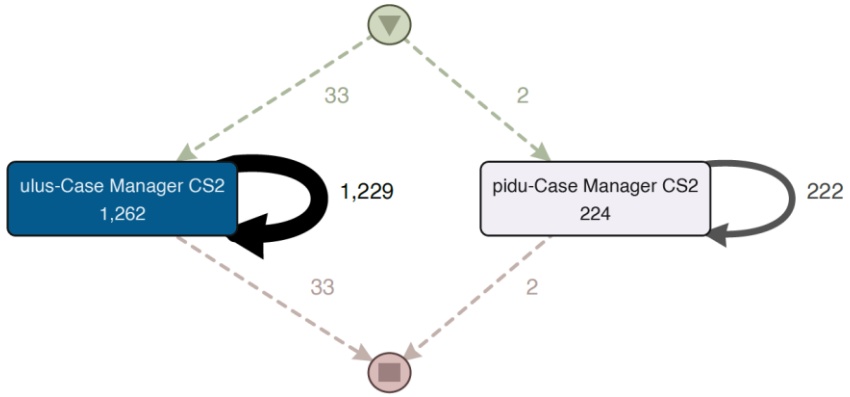
➜ Modeled task assignees could deviate from observed task processors



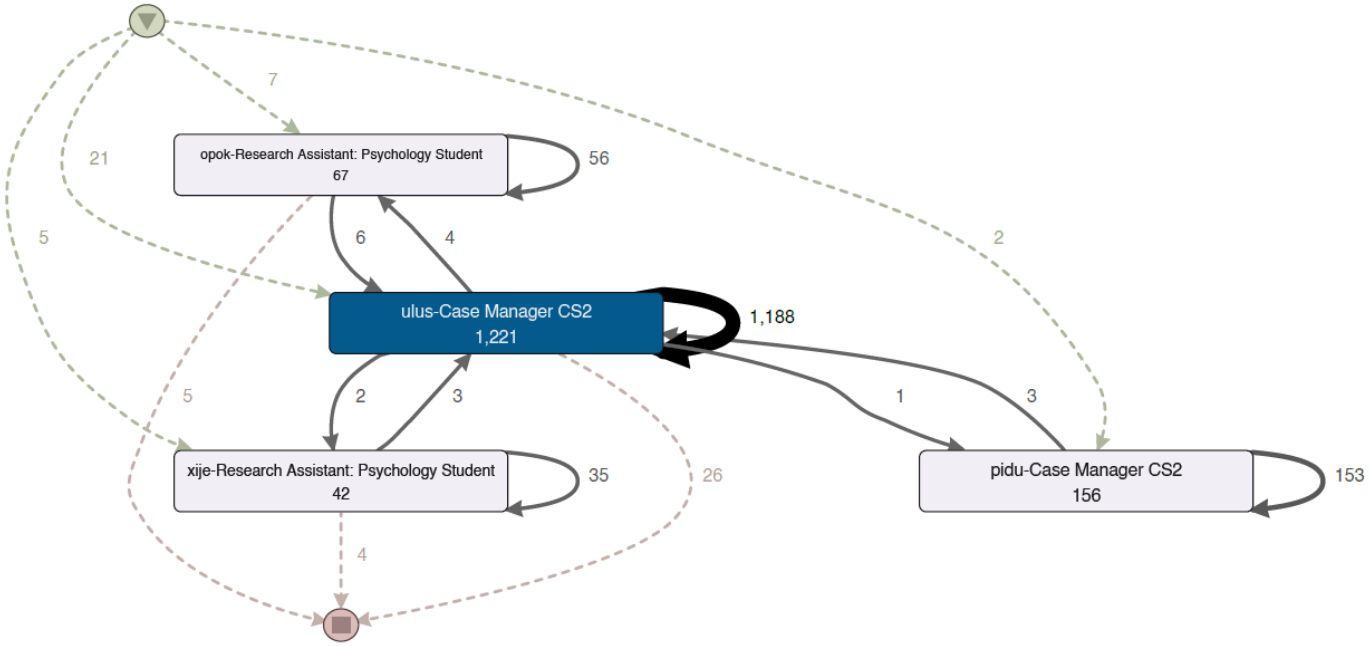
Indicator	Groningen		Tel-Aviv		Lleida	
	CS1	CS2	CS1	CS2	CS1	CS2
Number of tasks not done by their assignee	0	110	1 003	551	634	715
Share of tasks not done by their assignee	0%	37%	80%	57%	63%	68%
Number of task assignees	1	2	5	8	10	29
Number of task processors	1	4	3	9	9	6
Number of roles	1	2	2	3	5	4
Maximum share of work for one person	100%	83%	53%	37%	95%	98%
Mean number of collaborators per person	0	1.5	0.67	2.67	1.78	1.67
Maximum number of collaborators per person	1	3	1	6	8	5

RQ3 – How are collaboration and organization features reflected in case execution logs?

Groningen: Task Assignees vs. Task Processors



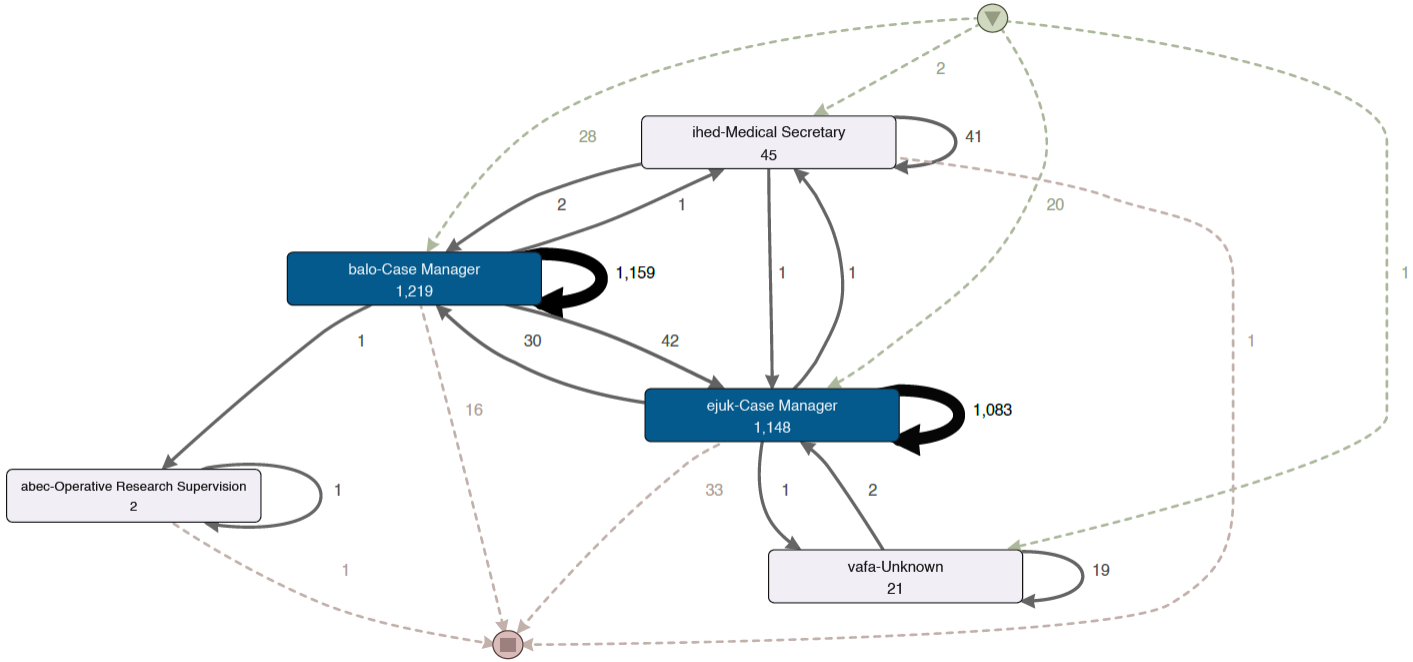
Groningen
Task Assignees - as modeled



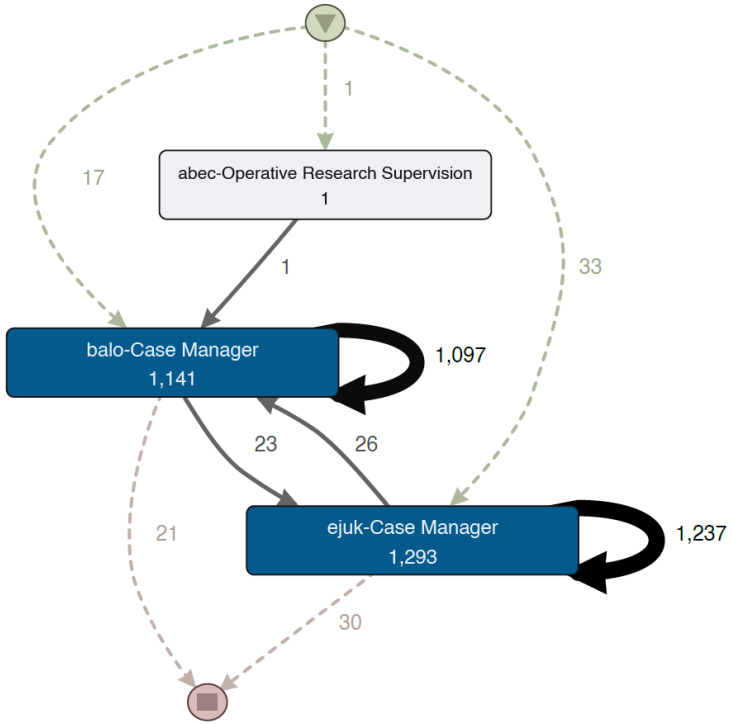
Groningen
Task Processors - as observed

RQ3 – How are collaboration and organization features reflected in case execution logs?

Tel-Aviv: Task Assignees vs. Task Processors



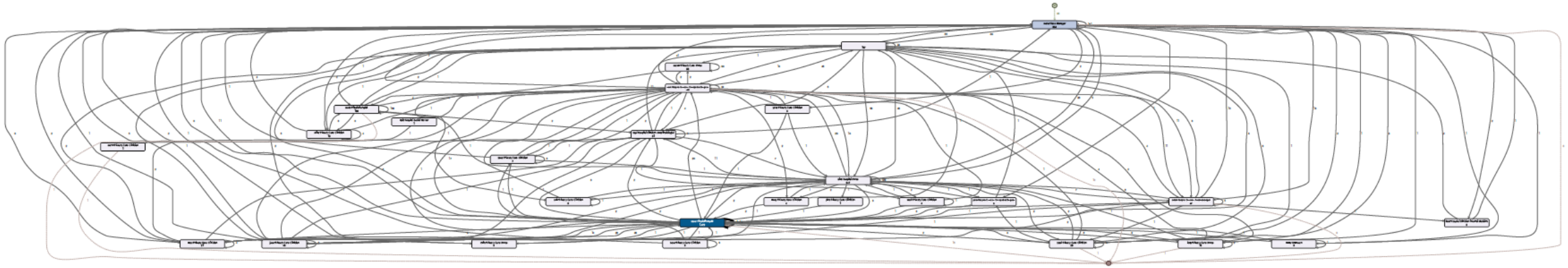
Tel-Aviv
Task Assignees – as modeled



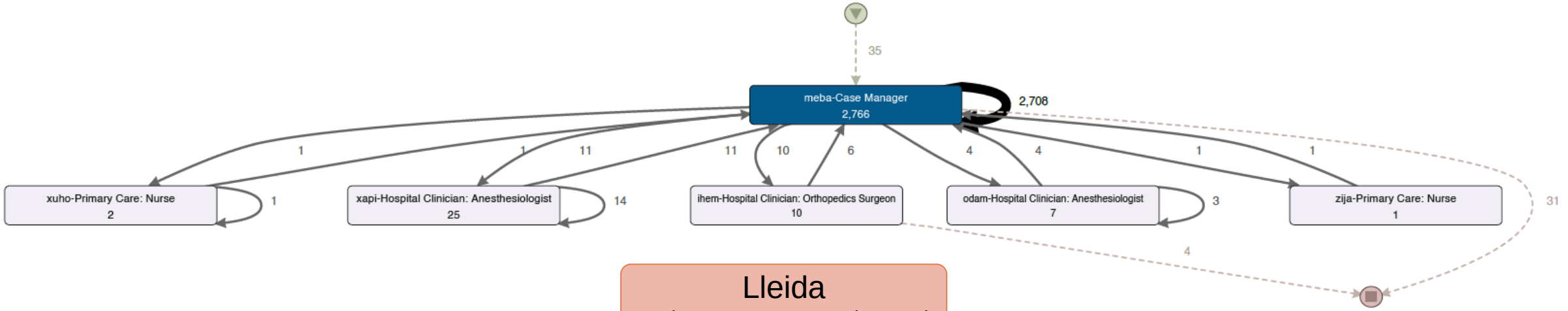
Tel-Aviv
Task Processors – as observed

RQ3 – How are collaboration and organization features reflected in case execution logs?

Lleida: Task Assignees vs. Task Processors



Lleida
Task Assignees – as modeled



Lleida
Task Processors – as observed

RQ3 – How are collaboration and organization features reflected in case execution logs?

Conclusion

➜ Contain **largest differences between modeled and observed behaviour**

➜ Complex models heavily deviate from reality

➜ All studies have one or two **central case managers** who distribute the work

➜ Overall, user and role management system used less than intended
(few users actually active in the system)

Conclusion & Future Work

Conclusion

- Flexibilities offered by the SACM system are clearly used in practice
- Observed flexibility increased with increased system usage
- Observed flexibility higher the more features were used and the more users were active
- Far less users active than intended during modeling

Limitations

- Case studies are still running
- Patient numbers and overall event count is comparably low (~25.000 vs. ~1 mil on avg)
- Actual PM step needs to be performed manually
- Infrastructure access needed to access event log

Future Work

- Repeat analysis when studies are finished
- Transfer system & evaluation to other hospitals
- Fully automate the process map generation
- Further deepen analysis
  - Focus on cases deviating from commonly followed paths
  - Focus on changes from version to version
  - Extend data logging to include proper user session tracking

B.Sc.

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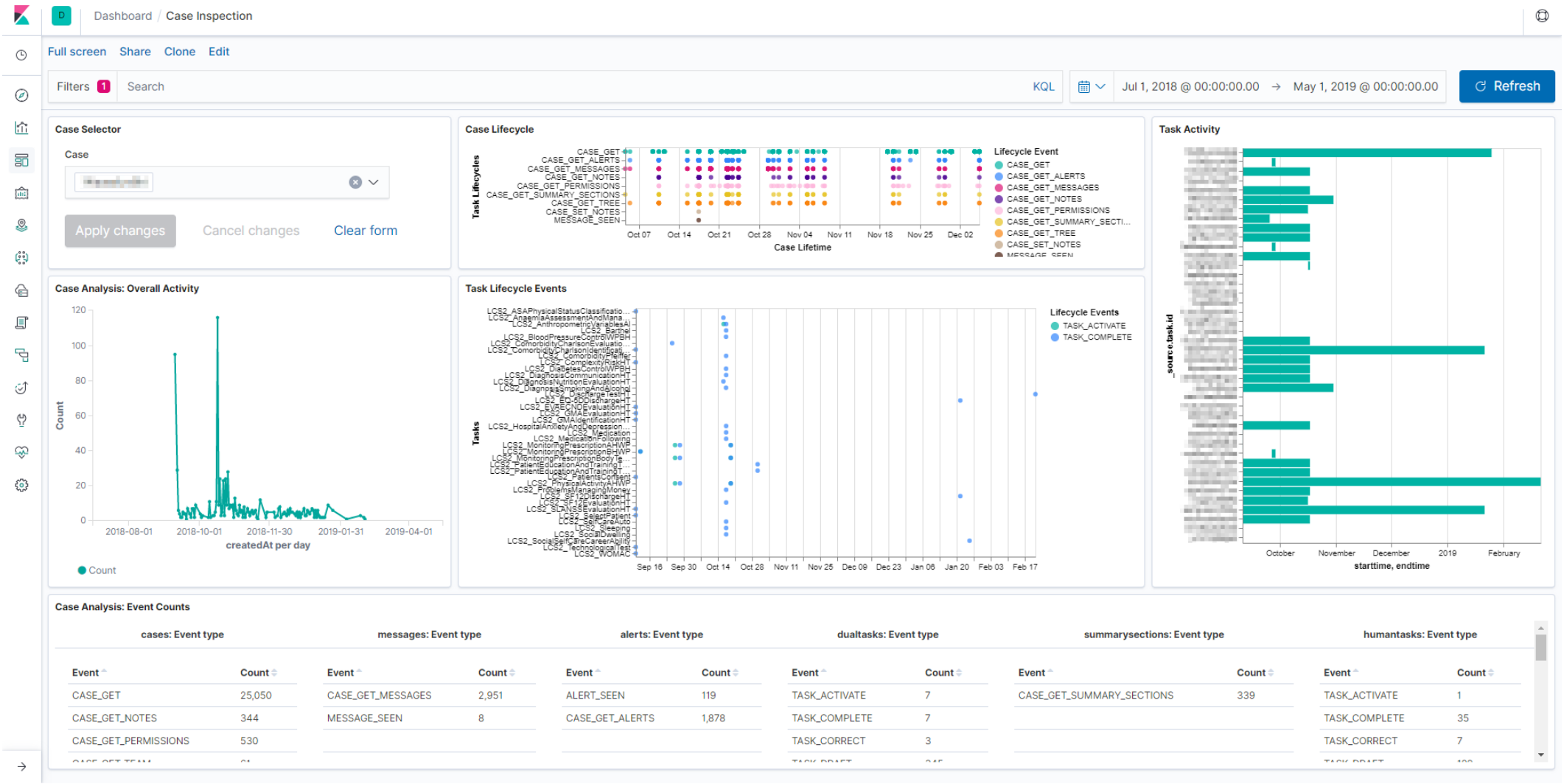
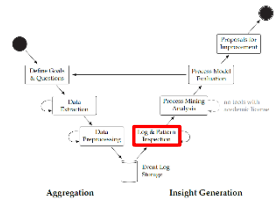
Backup

Implementation – Log and Pattern Inspection

Kibana showing Single Case Inspection





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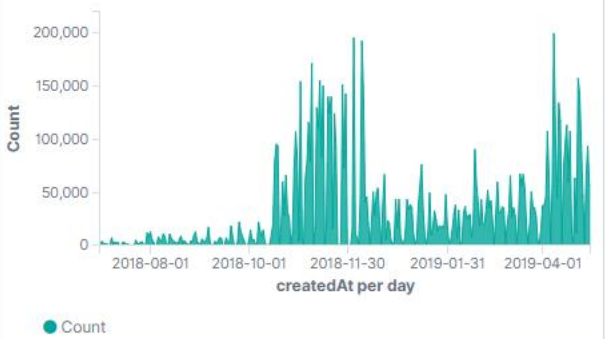
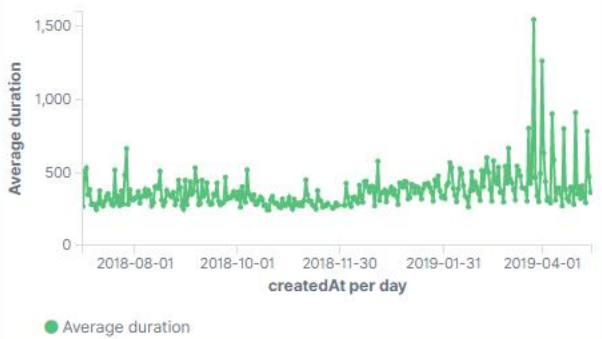
Filters Search KQL Jul 1, 2018 @ 00:00:00.00 → May 1, 2019 @ 00:00:00.00 Refresh

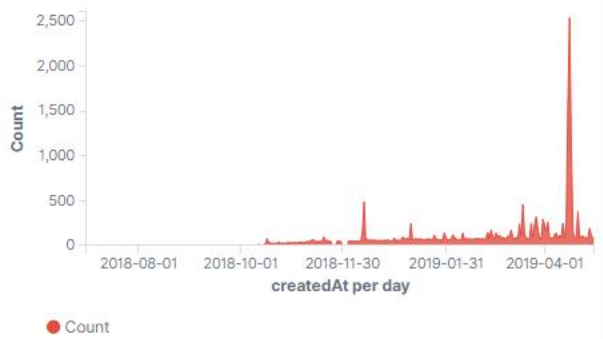
Number of requests



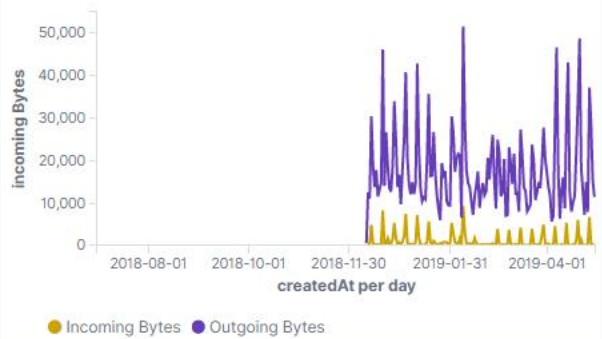
Mean response time in milliseconds



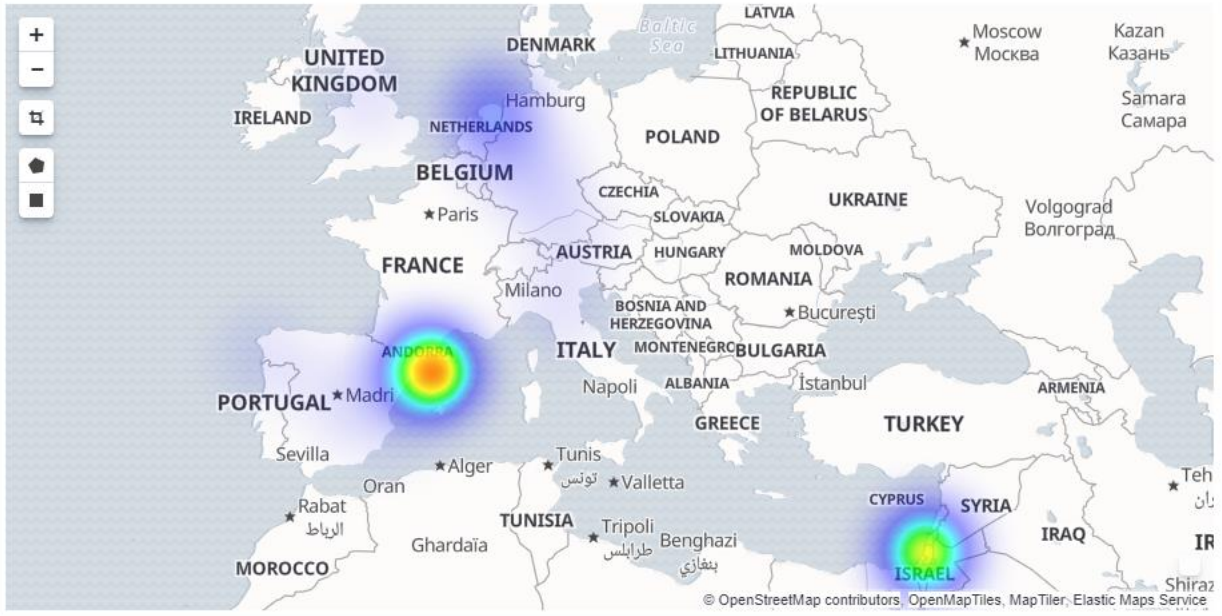
Number of HTTP error replies



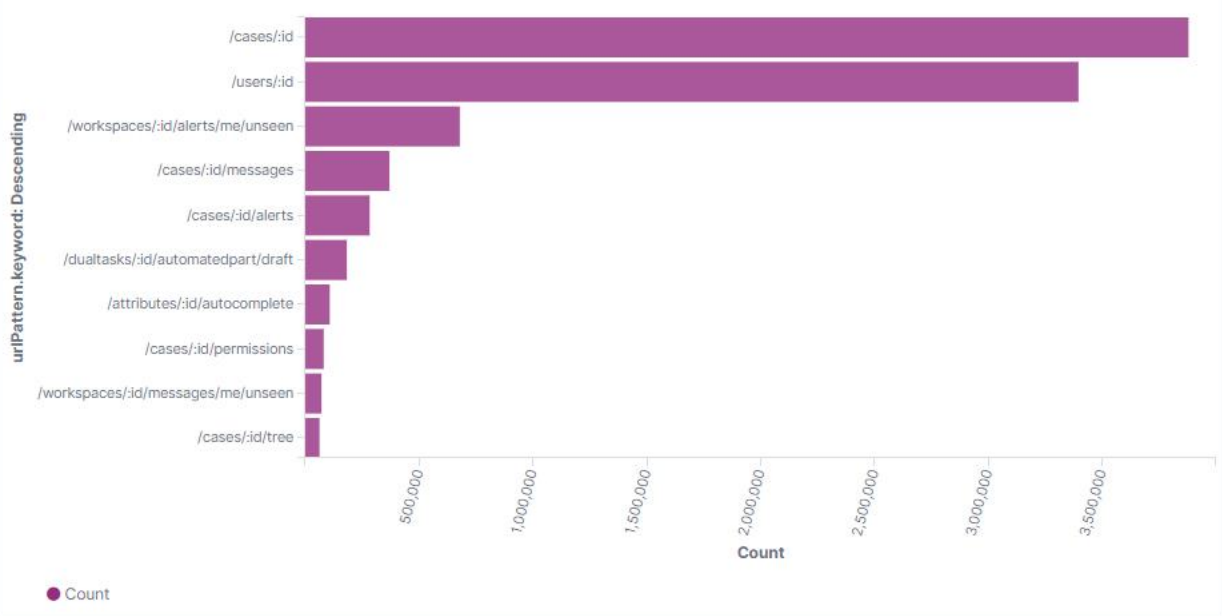
Transmitted bytes



Request origins



Most used REST endpoints



Full screen Share Clone Edit

Filters Search KQL Jul 1, 2018 @ 00:00:00.00 → May 1, 2019 @ 00:00:00.00 Refresh

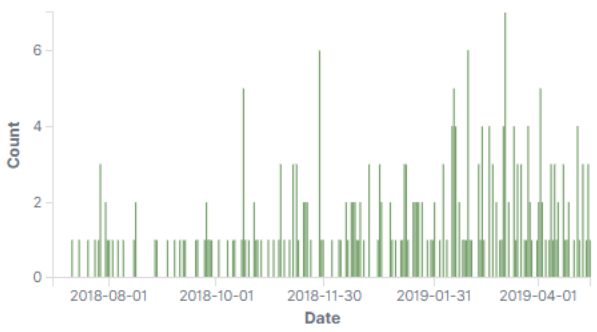
261
Case Creations

5,031
Completed Tasks

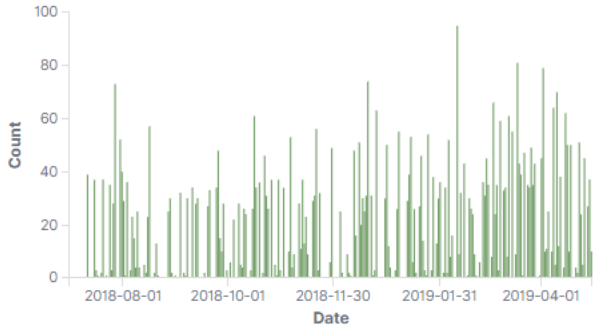
15,078
Received Alerts

64
Case Note Updates

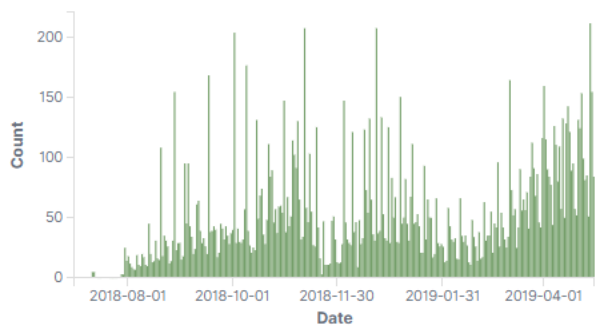
Case Creations



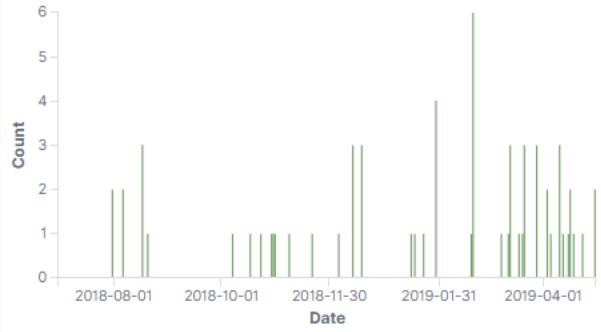
Completed Tasks



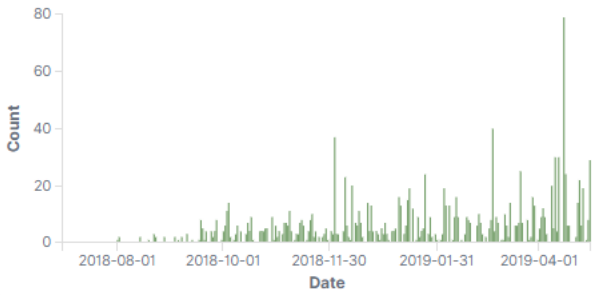
Received Alerts



Case Note Updates



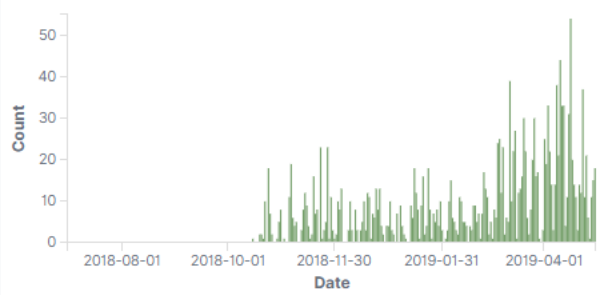
Team Messages



1,330
Team Messages

1,770
Patient Messages

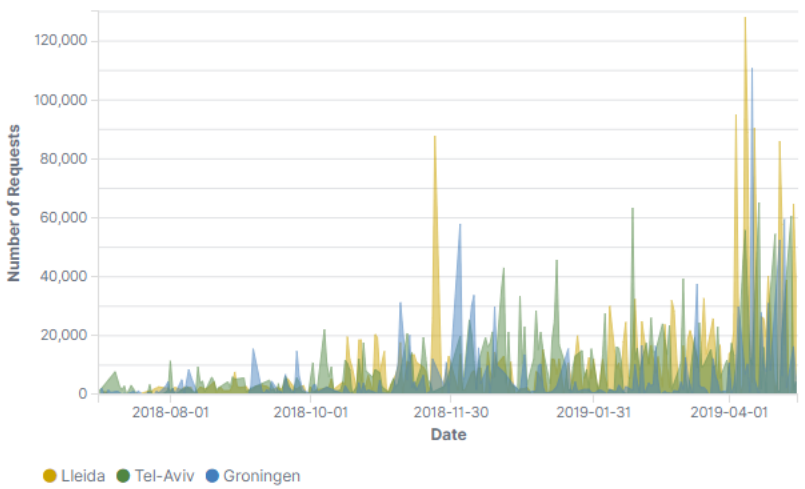
Patient Messages



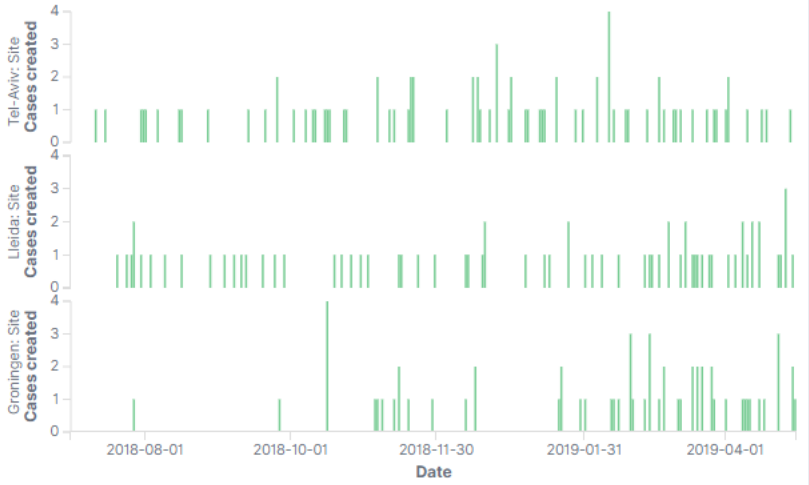
Full screen Share Clone Edit

Filters Search KQL Jul 1, 2018 @ 00:00:00.00 → May 1, 2019 @ 00:00:00.00 Refresh

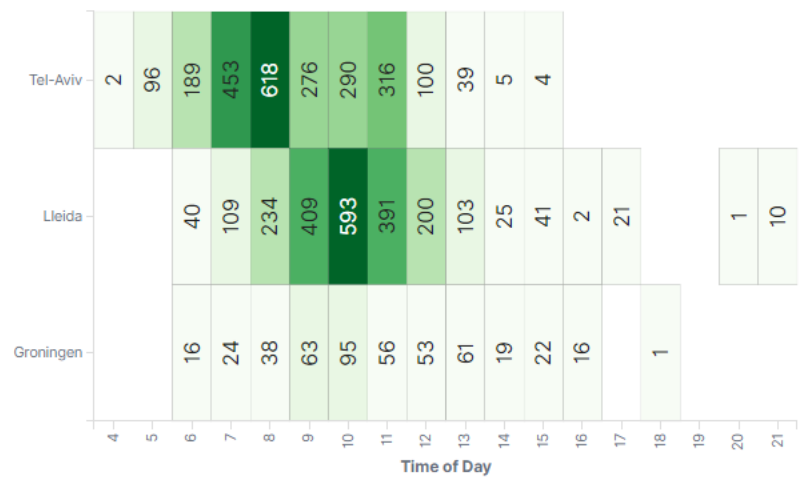
Number of Requests



Created Cases by Date



Completed Tasks by Time of Day



Event Counts by Case

Lleida: Site

Case ID	filters	Count
[redacted]	Tasks done	28
[redacted]	Team Messages	24
[redacted]	Patient Messages	33
[redacted]	Notes updated	3
[redacted]	Alerts seen	358
[redacted]	Tasks done	36
[redacted]	Team Messages	24
[redacted]	Patient Messages	97
[redacted]	Notes updated	1

Tel-Aviv: Site

Case ID	filters	Count
[redacted]	Tasks done	52
[redacted]	Team Messages	6
[redacted]	Patient Messages	3
[redacted]	Notes updated	0
[redacted]	Alerts seen	394
[redacted]	Tasks done	28
[redacted]	Team Messages	6
[redacted]	Patient Messages	11
[redacted]	Notes updated	0

Groningen: Site

Case ID	filters	Count
[redacted]	Tasks done	9
[redacted]	Team Messages	0
[redacted]	Patient Messages	0
[redacted]	Notes updated	0
[redacted]	Alerts seen	246
[redacted]	Tasks done	10
[redacted]	Team Messages	0
[redacted]	Patient Messages	0
[redacted]	Notes updated	0

Filters 1 | Search | KQL | Jul 1, 2018 @ 00:00:00.00 → May 1, 2019 @ 00:00:00.00 | Refresh

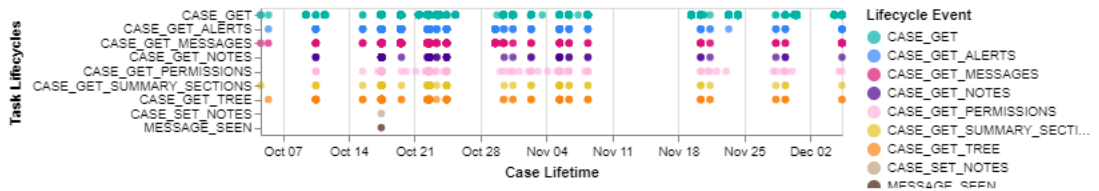
Case Selector

Case

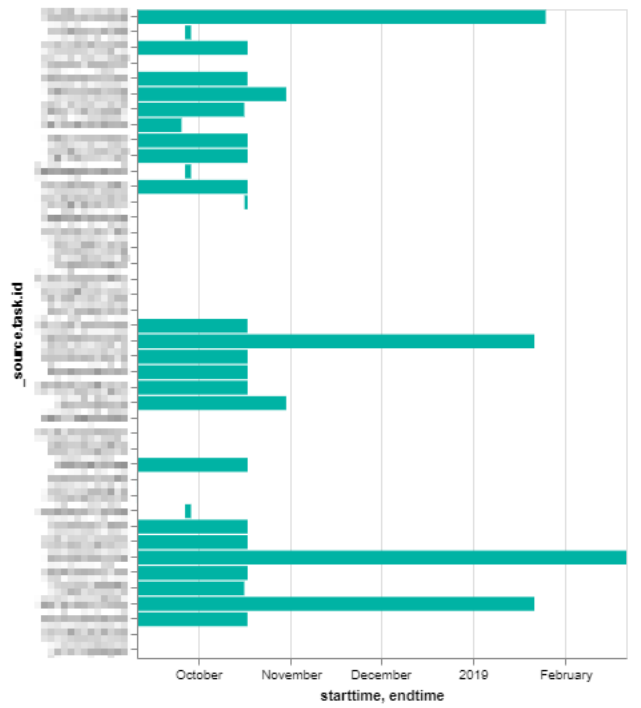
[redacted]

Apply changes | Cancel changes | Clear form

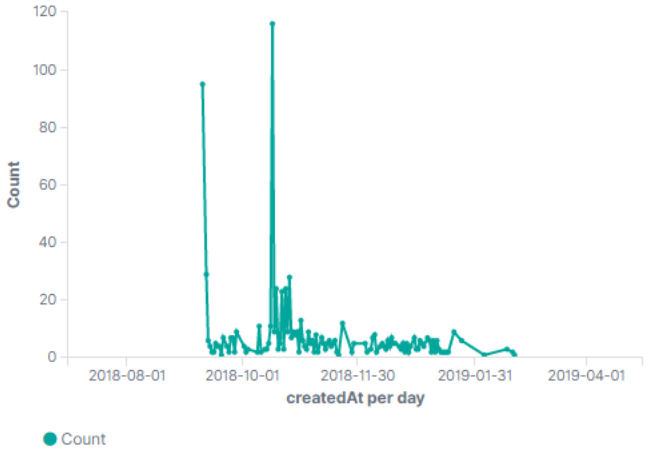
Case Lifecycle



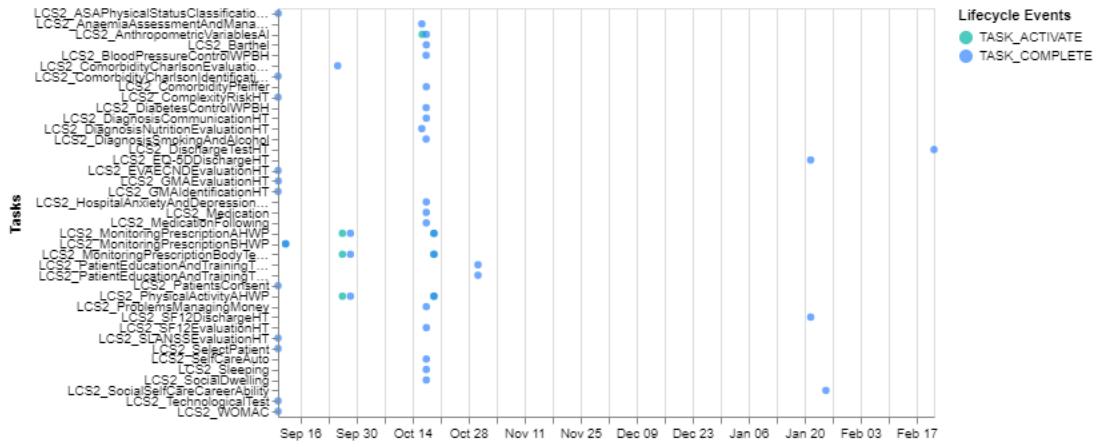
Task Activity



Case Analysis: Overall Activity



Task Lifecycle Events



Case Analysis: Event Counts

cases: Event type

Event	Count
CASE_GET	25,050
CASE_GET_NOTES	344
CASE_GET_PERMISSIONS	530

messages: Event type

Event	Count
CASE_GET_MESSAGES	2,951
MESSAGE_SEEN	8

alerts: Event type

Event	Count
ALERT_SEEN	119
CASE_GET_ALERTS	1,878

dualtasks: Event type

Event	Count
TASK_ACTIVATE	7
TASK_COMPLETE	7
TASK_CORRECT	3

summarysections: Event type

Event	Count
CASE_GET_SUMMARY_SECTIONS	339

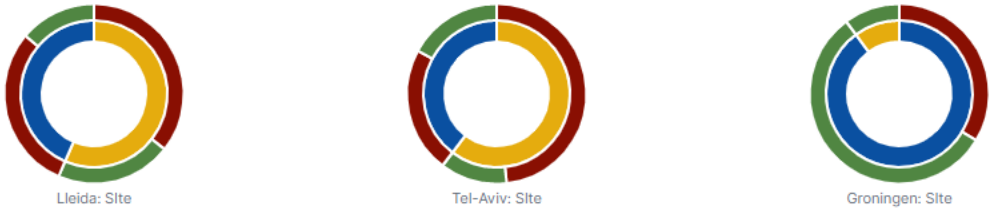
humantasks: Event type

Event	Count
TASK_ACTIVATE	1
TASK_COMPLETE	35
TASK_CORRECT	7

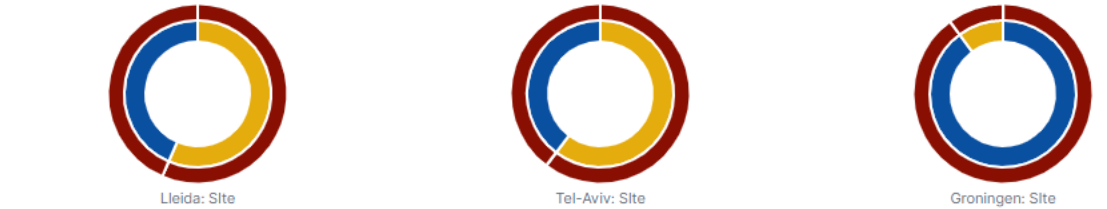
Full screen Share Clone Edit

Filters Search KQL Jul 1, 2018 @ 00:00:00.00 → May 1, 2019 @ 00:00:00.00 Refresh

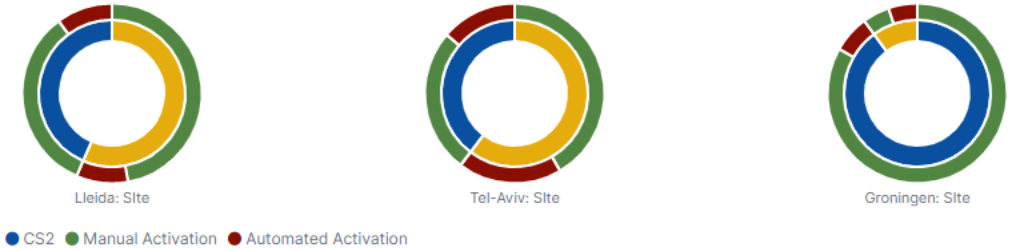
GQFI RQ3: Tasks not done by assignee



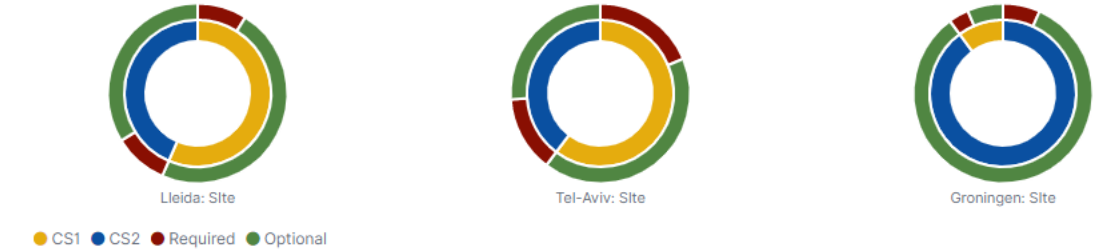
GQFI RQ3: Tasks with overwritten assignees



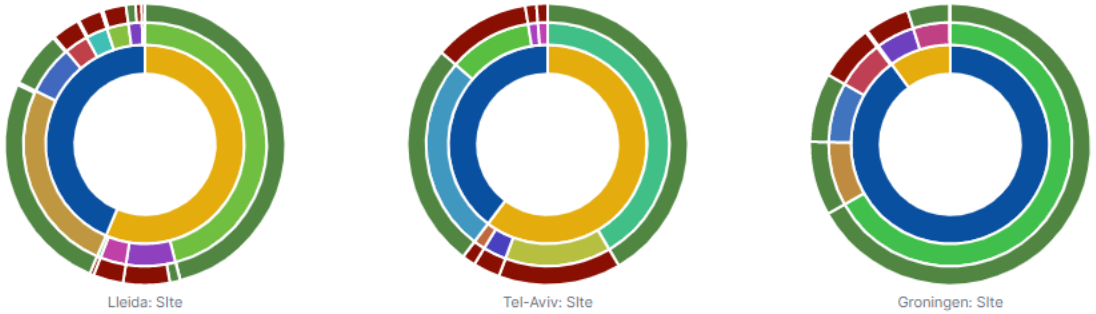
GQFI RQ1: Manually activated tasks - by case



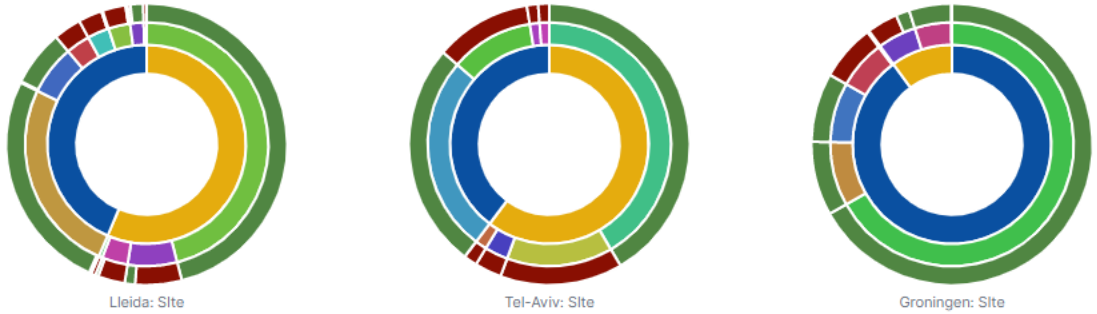
GQFI RQ1: Optional tasks - by case



GQFI RQ1: Manually activated tasks - by stage



GQFI RQ1: Optional tasks - by stage



Discover

24,154 hits

New Save Open Share Inspect

Filters Search KQL Jul 1, 2018 @ 00:00:00.00 → May 1, 2019 @ 00:00:00.00 Refresh

event-log

Selected fields

? _source

Available fields

Popular

requestLocation

@timestamp

t @version

t _id

t _index

_score

t _type

t activity

activityEnd

t activityId

activityStart

t activityType

t alertId

t alertType

t caseDefinitionId

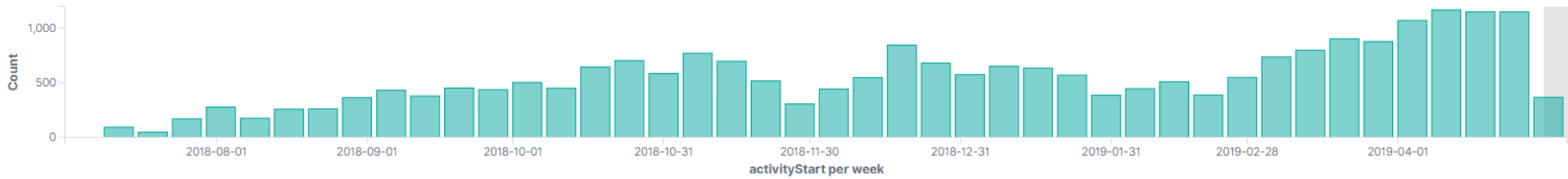
t caseDefinitionName

t caseId

caseMessageCount

t clinicalStudyVersion

Jul 1, 2018 @ 00:00:00.000 - May 1, 2019 @ 00:00:00.000 — Weekly



Time	_source
Apr 30, 2019 @ 22:15:58.000	messageAuthorId: [redacted] activityEnd: Apr 30, 2019 @ 22:15:58.000 @timestamp: Jun 2, 2019 @ 10:57:02.338 caseMessageCount: 10 messageHasAttachment: false messageAuthorGroups: [redacted] patientId: [redacted] site: Lleida caseDefinitionName: LCS1_Leida_7 messageAuthorRole: Patient activityStart: Apr 30, 2019 @ 22:15:58.000 @version: 1 activity: Patient clusterGroupCase: LCS1v4 caseId: [redacted] activityId: [redacted] activityType: Message caseDefinitionId: [redacted] messageId: [redacted] messageAuthorGroupsJoined: [redacted] _id: [redacted] _type: _doc _index: event-log _score: - clinicalStudyVersion: CS1 hoursOfDay: 20 millisOfDay: 72,958,000
Apr 30, 2019 @ 20:33:07.000	taskOwnerRole: [redacted] activityEnd: Apr 30, 2019 @ 20:33:07.000 @timestamp: Jun 2, 2019 @ 14:48:33.113 caseMessageCount: 4 tags: emulated patientId: [redacted] taskRepeatability: PARALLEL alertType: CUSTOM taskOwnerGroups: [redacted] taskActivation: MANUAL activity: MonitoringPrescriptionSP02 taskId: [redacted] taskOwnerId: [redacted] clusterGroupCase: LCS1v4 caseId: [redacted] stageRepeatability: ONCE activityType: Alert caseDefinitionId: [redacted] taskIsRequired: false taskIsDone: false taskName: MonitoringPrescriptionSP02 requestUserRole: [redacted] taskOwnerGroupsJoined: [redacted] taskAlertCount: 41 stageName: Workplan caseDefinitionName: LCS1_Leida_7 site: Lleida taskOwnerIsOverridden: false clusterGroupStage: LCS1v9_Workplan stageIsRequired: true activityStart: Apr 30, 2019 @

Expanded document

View surrounding documents View single document

Table JSON


```
{
  "_index": "event-log",
  "_type": "_doc",
  "_id": "[redacted]",
  "_version": 2,
  "_score": null,
  "_source": {
    "taskOwnerRole": "[redacted]",
    "activityEnd": "2019-04-30T18:33:07.000Z",
    "@timestamp": "2019-06-02T12:48:33.113Z",
```

Save Share Inspect Refresh

Filters 5 | Search | Lucene | Jul 1, 2018 @ 00:00:00.00 → May 1, 2019 @ 00:00:00.00 | Refresh

status: 200 to 299 × | NOT application: UIM × | isTestUser: false × | isSimulateUser: false × | site.keyword is one of Lleida, Tel-Aviv, Groningen × | + Add filter

api-access-logs*

Data | Metrics & Axes | Panel Settings

Metrics

Y-Axis Count

Add metrics

Buckets

Split Series

Aggregation — Terms help

Terms

Field

site.keyword

Order By

metric: Number of Requests

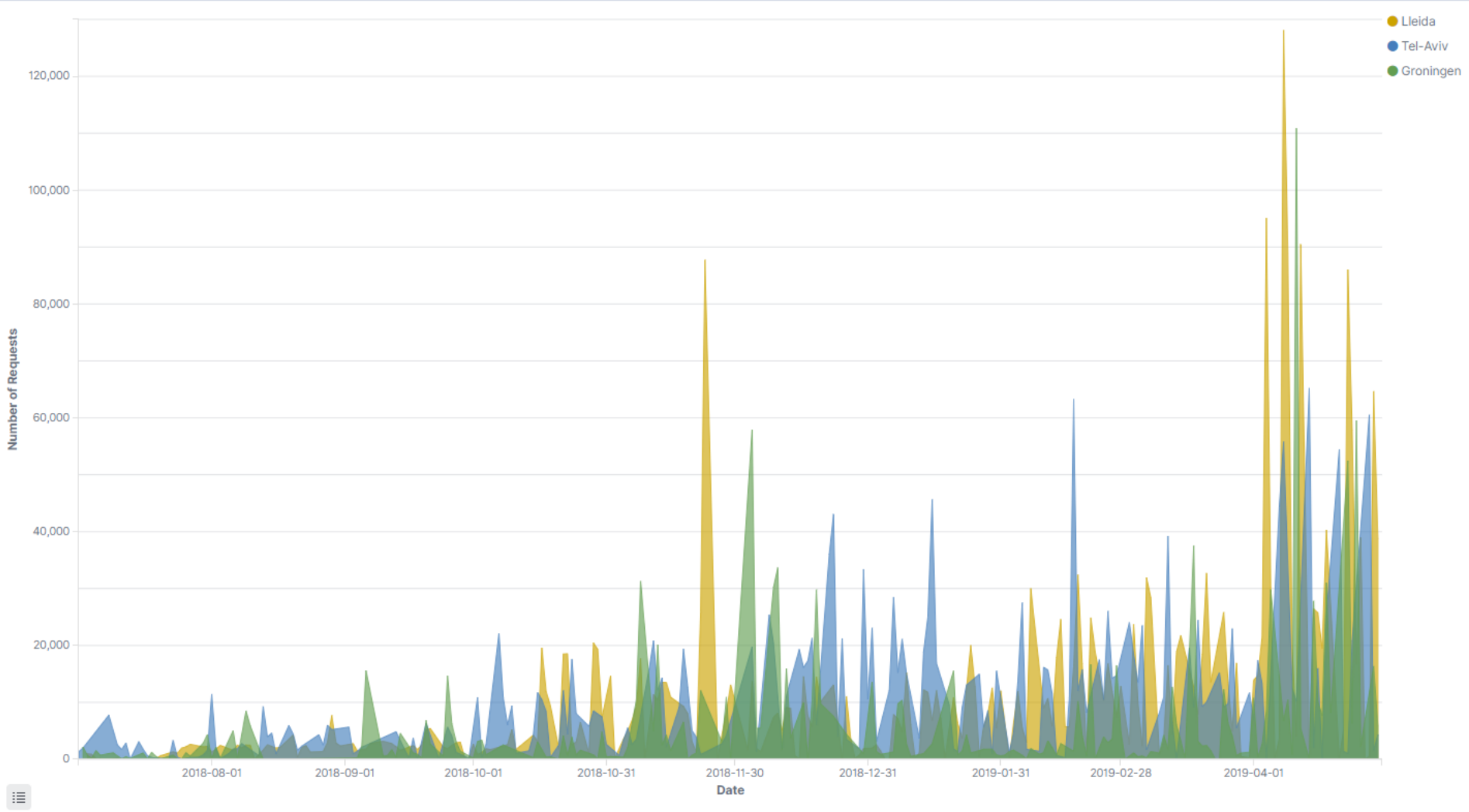
Order: Descen | Size: 5

Group other values in separate bucket

Show missing values

Custom Label

Advanced



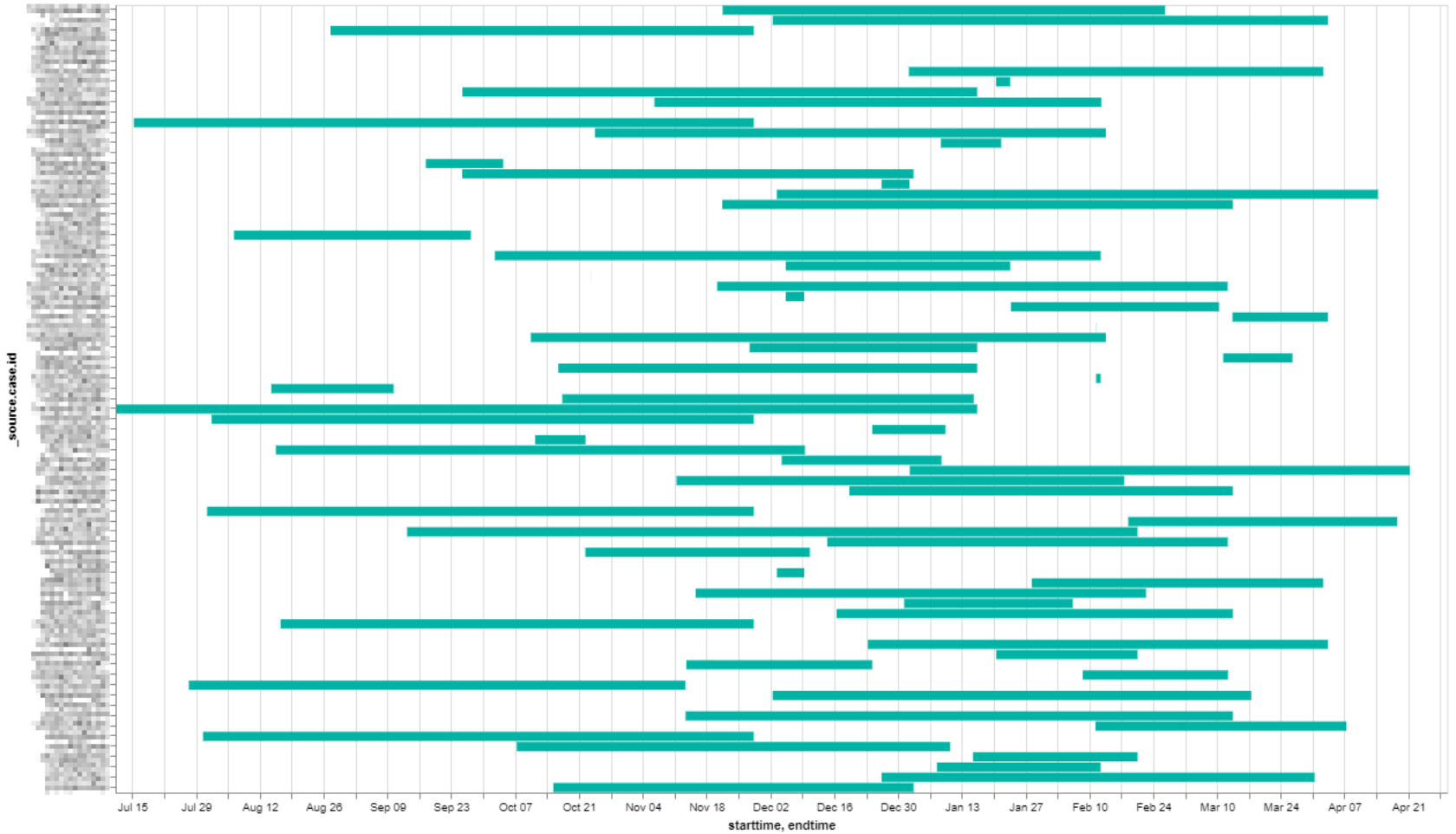
Save Share Inspect Refresh

Filters 3 | Search | Lucene | Jul 1, 2018 @ 00:00:00.00 → May 1, 2019 @ 00:00:00.00 | Refresh

event is one of CASE_TERMINATE, CASE_COMPLETE × | status: 200 to 299 × | + Add filter

This visualization is marked as experimental. Have feedback? Please create an issue in GitHub.

```
{
  $schema: https://vega.github.io/schema/vega-lite/v2.json
  description: A simple bar chart with ranged data (aka Gantt Chart).
  data: {
    # URL object is a context-aware query to Elasticsearch
    url: {
      # The %-enclosed keys are handled by Kibana to modify the query
      # before it gets sent to Elasticsearch. Context is the search
      # filter as shown above the dashboard. Timefield uses the value
      # of the time picker from the upper right corner.
      %context%: true
      %timefield%: createdAt
      index: api-access-logs*
      body: {
        size: 10000
        _source: ["createdAt", "event", "case.id", "case.activeDate", "case
          .terminatedDate", "case.name"]
      }
    }
    # We only need the content of hits.hits array
    format: {property: "hits.hits"}
#    "values": [
#      {"task": "A","start": 1, "end": 3},
#      {"task": "B","start": 3, "end": 8},
#      {"task": "C","start": 8, "end": 10}
#    ]
  }
  # Parse timestamp into a javascript date value
  transform: [
    {filter: "datum._source['event'] == 'CASE_TERMINATE' || datum
      ._source['event'] == 'CASE_COMPLETE'"}
    {filter: "datum._source['case']"}
    {calculate: "toDate(datum._source['case']['activeDate'])", as:
      "starttime"}
    {calculate: "toDate(datum._source['case']['terminatedDate'])", as:
      "endtime"}
  ]
  mark: bar
  encoding: {
    y: {field: "_source.case.id", type: "nominal"}
    x: {field: "starttime", type: "temporal"}
    x2: {field: "endtime", type: "temporal"}
  }
}
```



Challenges of Process Mining in Healthcare – Data Quality Issues

- Causes
  - **Abundance** and redundancy of data
  - **Cross-system** data extraction
  - Incorrect and insufficient logging
- Mitigations
  - Evaluating an integrated care environment
  - Mining **RESTful web service logs**
  - **Preprocessing events continuously** in near real-time

Implementation – Goal-Question-Feature-Indicator (GQFI) Table

Research Question 1
How is the model-provided flexibility employed during the execution of cases?

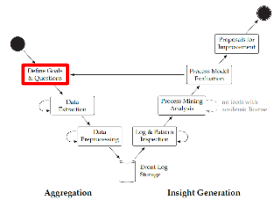
PM Feature	Indicator
Log and Pattern Inspection	Number of cases/events/activities
	Number of manually activated tasks
	Share of manually activated tasks
Process Discovery	Number of overall paths
	Mean number of paths per activity
	Number of bidirectional paths
Process Exploration	Number of process variants
	Maximum share of cases per variant
Performance Analysis	Median/mean case duration
	Standard deviation of case duration

Research Question 2
How do communication and notification features affect case executions?

PM Feature	Indicator
Log and Pattern Inspection	Number of notes update events
	Number of alert events
	Number of message events (with professionals/patients)
	Share of feature-related events
Process Discovery	Mean number of paths per alert activity
	Mean number of paths per message activity
	Mean number of paths per other activity

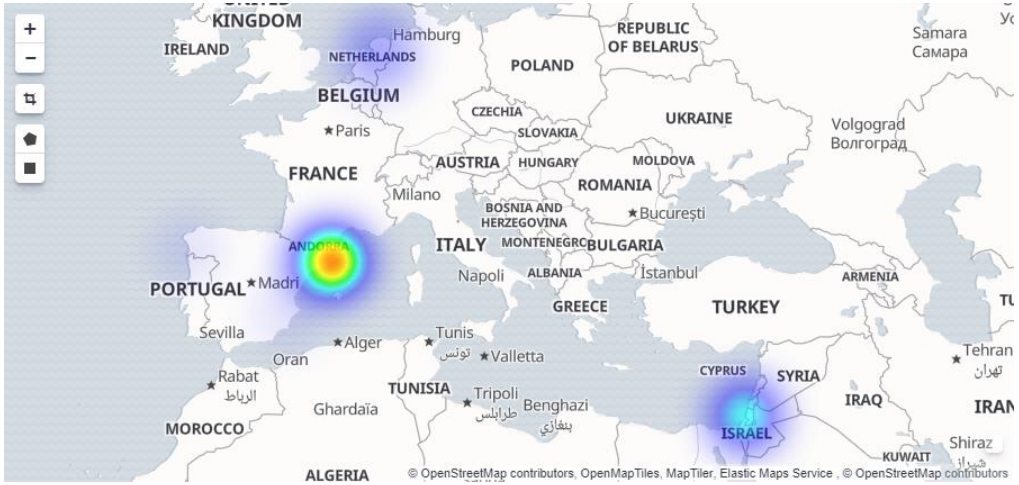
Research Question 3
How are collaboration and organization features reflected in case executions?

PM Feature	Indicator
Log and Pattern Inspection	Number/Share of tasks not done by their assignee
	Number of task assignees/task processors
	Number of roles
Organizational Analysis	Maximum share of work for one person
	Mean number of collaborators per person
	Maximum number of collaborators per person

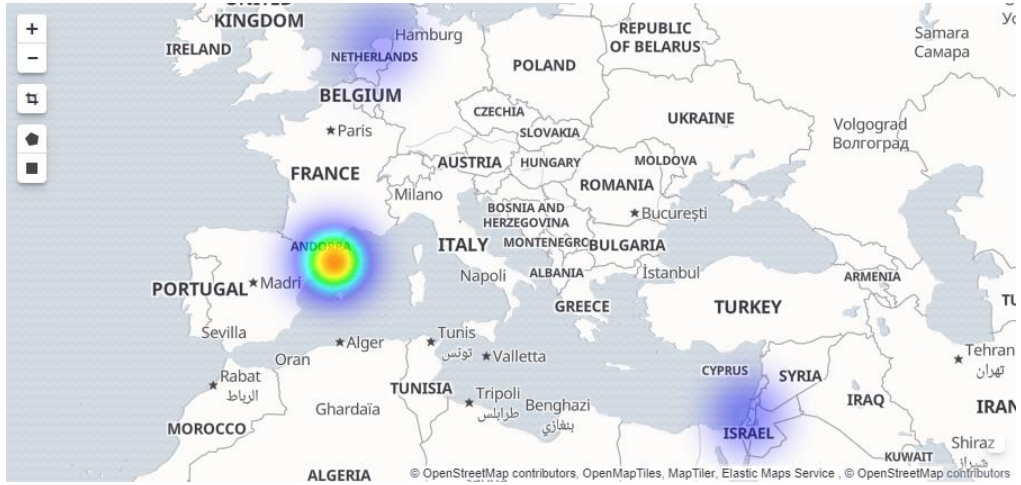


RQ2 – How do communication and notification features affect case executions?

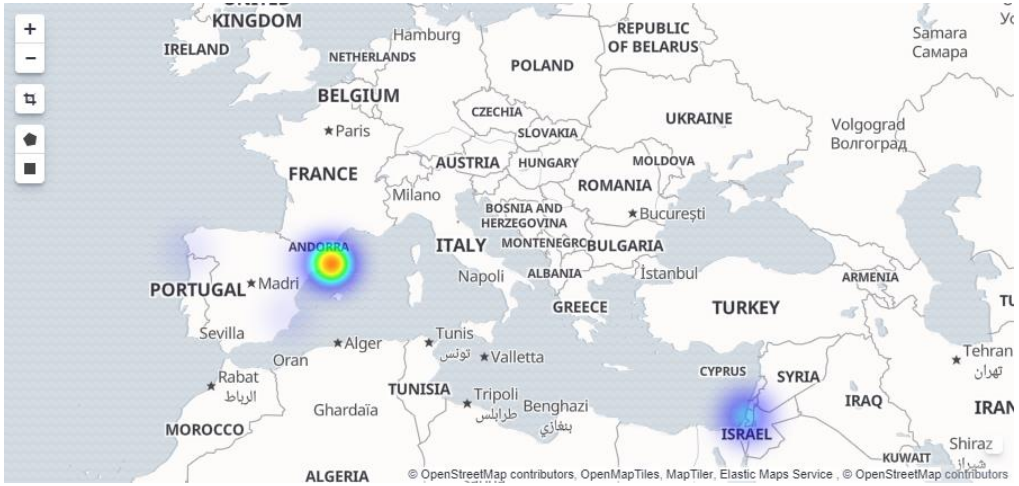
GeoIP Analysis



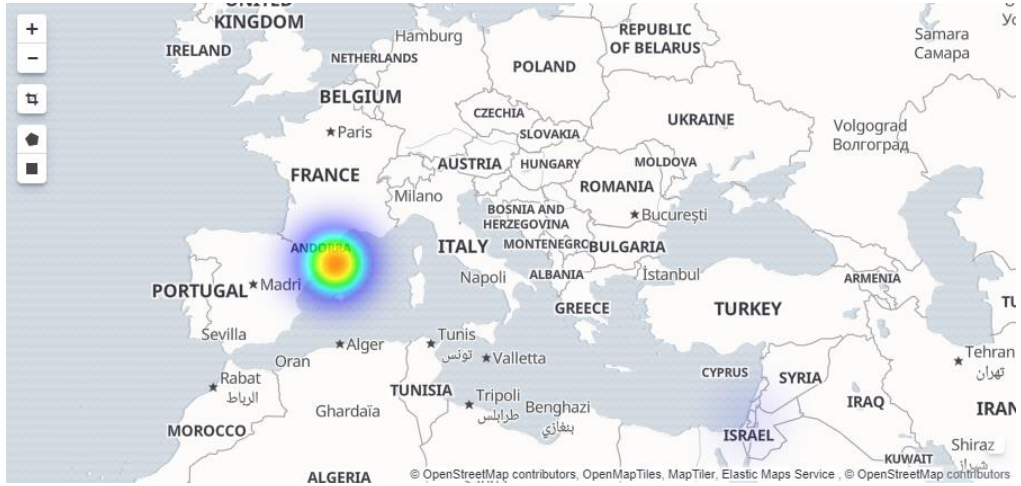
Overall Activity



Alert Activity



Message Activity



Notes Activity

RQ2 – How do communication and notification features affect case executions?

Process Map: System View (28% paths)