A Framework for Recommending Resource Allocation Based on Process Mining

MICHAEL ARIAS

ERIC ROJAS

JORGE MUNOZ-GAMA

MARCOS SEPÚLVEDA

Outline

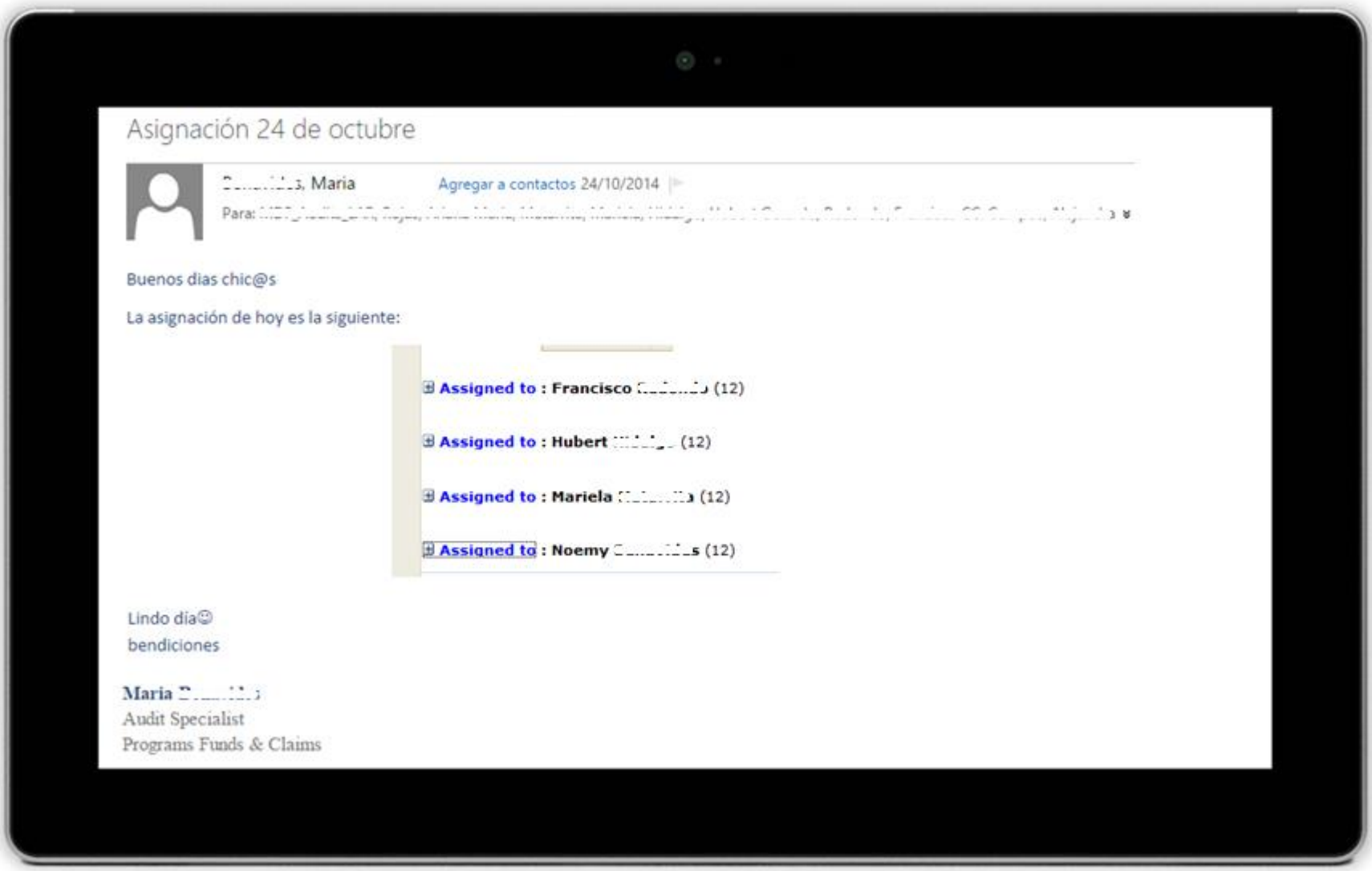
- Introduction
- Approach
  - General approach
  - Resource allocation request
  - Resource process cube and allocation metrics
  - Implementation
- Experimental evaluation
- Future work
- Conclusions

Outline

Motivation


Resources
Business processes
Cost reduction
Improve performance

Motivation


Asignación 24 de octubre
Maria
Agregar a contactos 24/10/2014
Buenos dias chic@s
La asignación de hoy es la siguiente:
Assigned to : Francisco (12)
Assigned to : Hubert (12)
Assigned to : Mariela (12)
Assigned to : Noemy (12)
Lindo día
bendiciones
Maria
Audit Specialist
Programs Funds & Claims

Related work

Human resource allocation: an important issue in Business Process Management

Resource patterns

[1] Russell et al. 2005

Machine learning

[5] Liu et al. 2008

Markov models

[6] Huang et al. 2011

[7] Koschmider et al. 2011

Data mining

[2] Rinderle-Ma and van der Aalst. 2007

[3] Huang et al. 2011

[4] Liu et al. 2012

Preference model

[8] Cabanillas et al. 2013

Related work

	[1]	[2]	[5]	[6]	[7]	[3]	[4]	[8]	Proposed
Activity profile		✓							✓
Resource profile	✓	✓			✓			✓	✓
Performance & quality									✓
Resource meta-model	✓				✓			✓	✓
History	✓	✓	✓	✓	✓	✓	✓	✓	✓
Process mining tool		✓			✓				✓
Allocation at sub-process level									✓

Related work

Research challenges

Dynamically allocation [9]	At real-time Real data with organizational models
Multi-factor	Flexible and extensible methods Use different criteria
Multi-level	Allocation an activity, process or sub-process level

[9] Zhao, W., Zhao, X.: Process mining from the organizational perspective, 2014

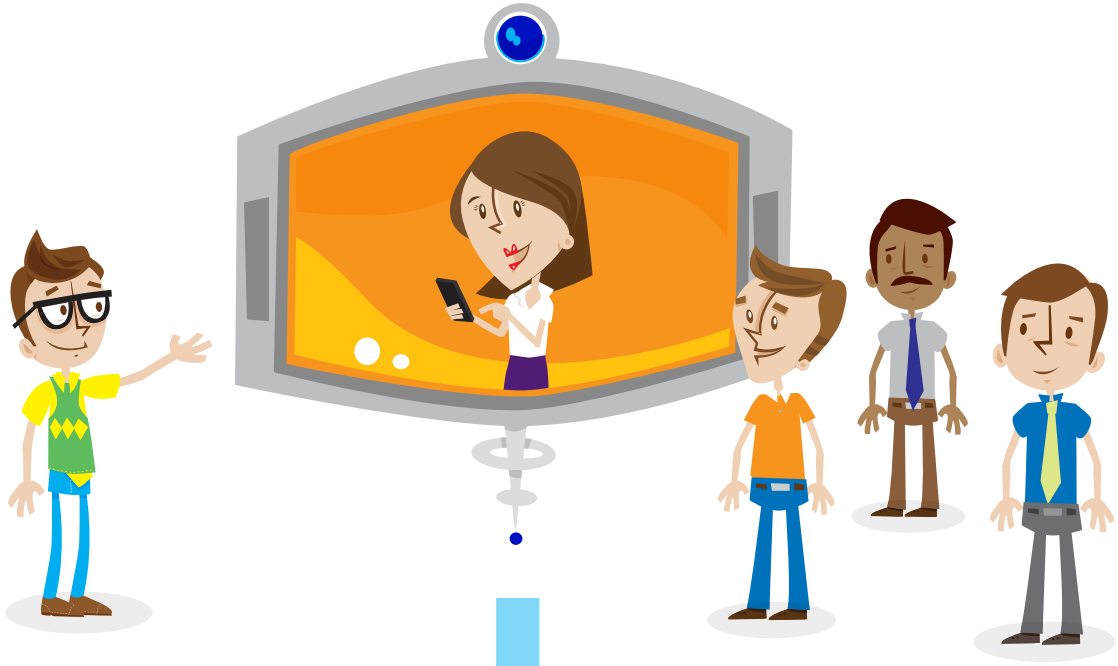
Related work

	[1]	[2]	[5]	[6]	[7]	[3]	[4]	[8]	Proposed
Activity profile		✓							✓
Resource profile	✓	✓			✓			✓	✓
Performance & quality									✓
Resource meta-model	✓				✓			✓	✓
History	✓	✓	✓	✓	✓	✓	✓	✓	✓
Process mining tool		✓			✓				✓
Allocation at sub-process level									✓

General idea

- Activity profile
- Resource profile
- Performance & Quality
- Resource meta-model
- History
- Process mining tool
- Allocation at sub-process level

Allocate the most appropriate resource



Framework for recommending resource allocation

Outline

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Approach

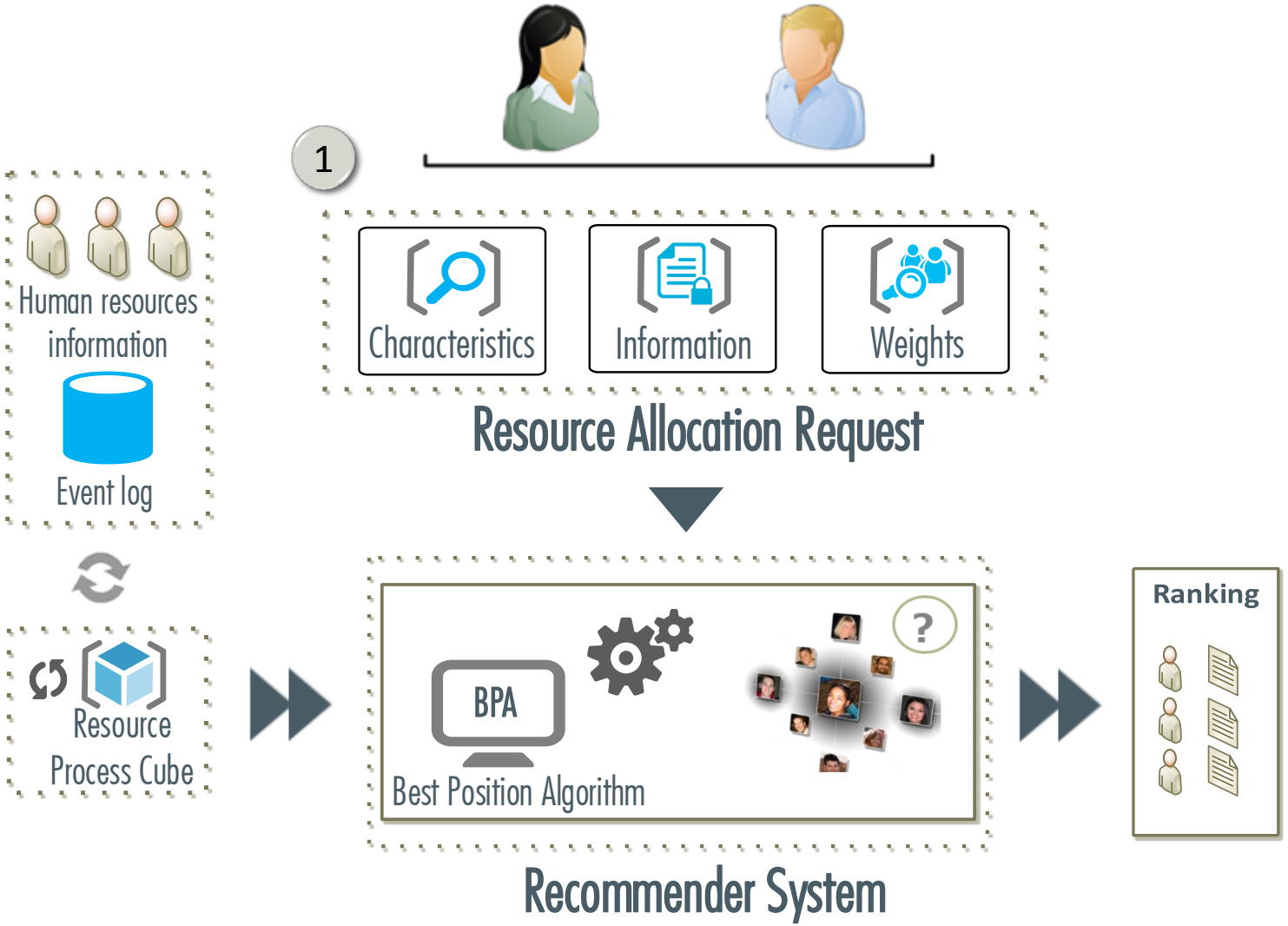
- General approach
- Resource allocation request
- Resource process cube and allocation metrics
- Implementation

Experimental evaluation

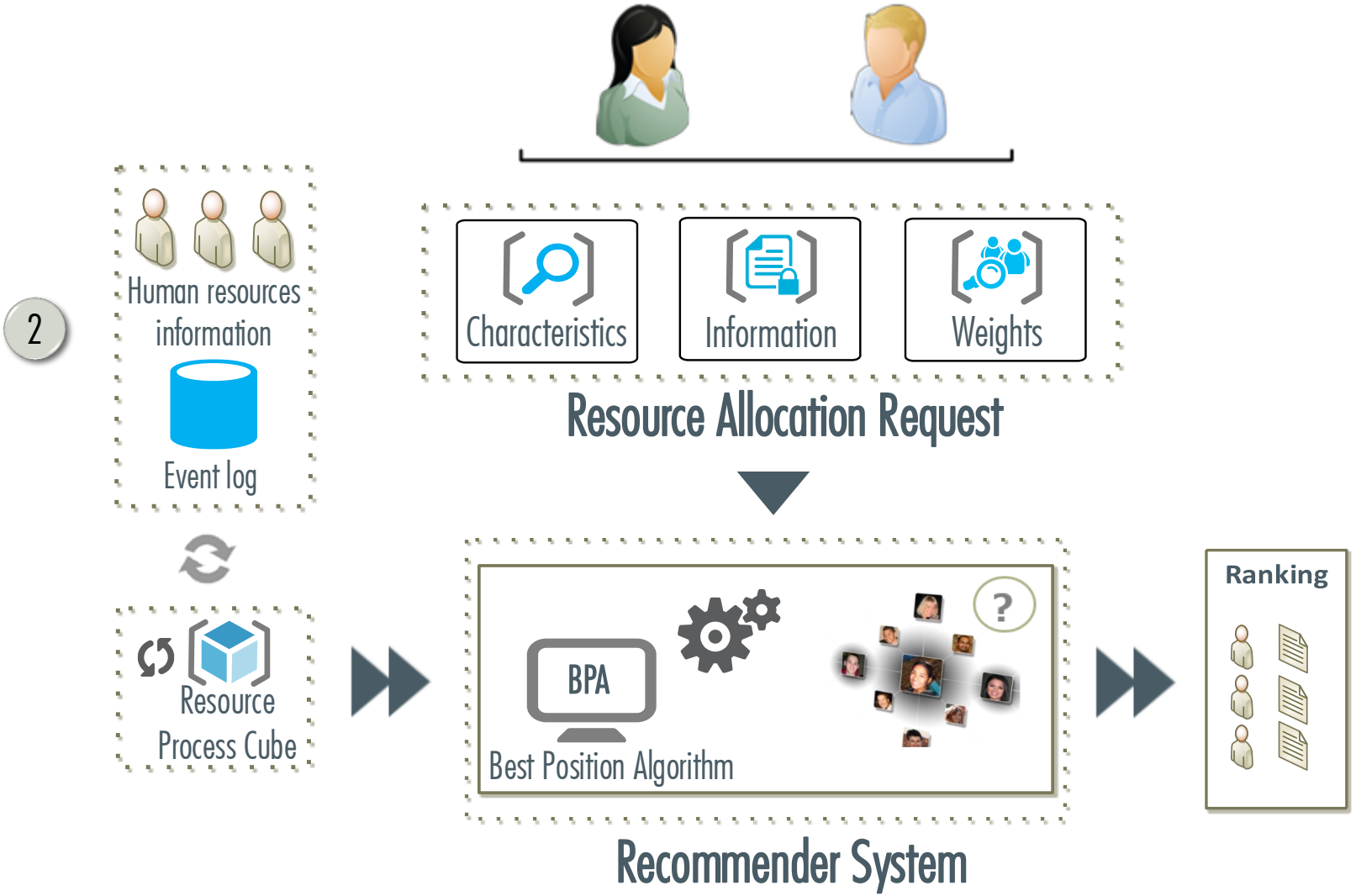
Future work

Conclusions

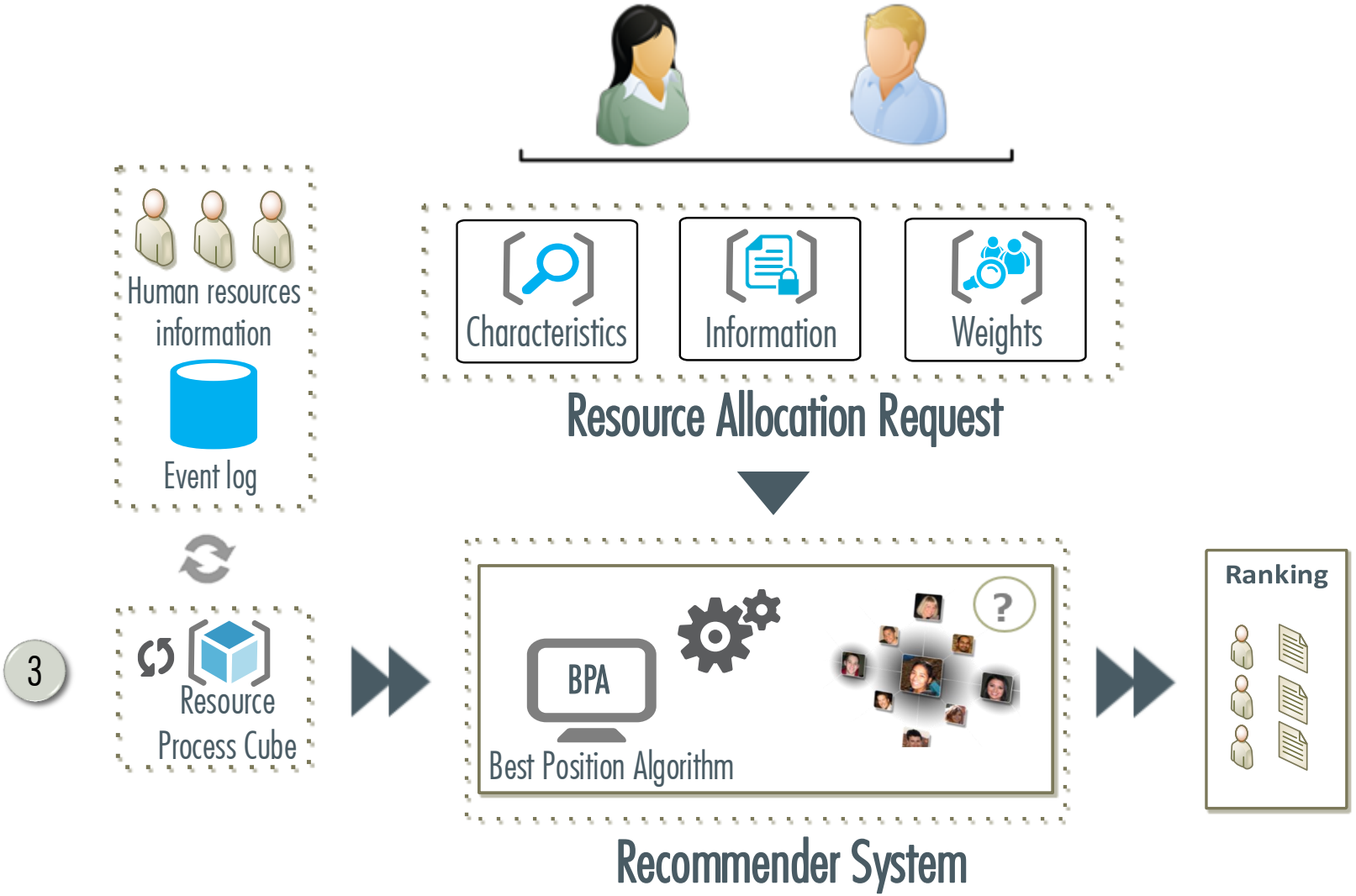
Proposed framework



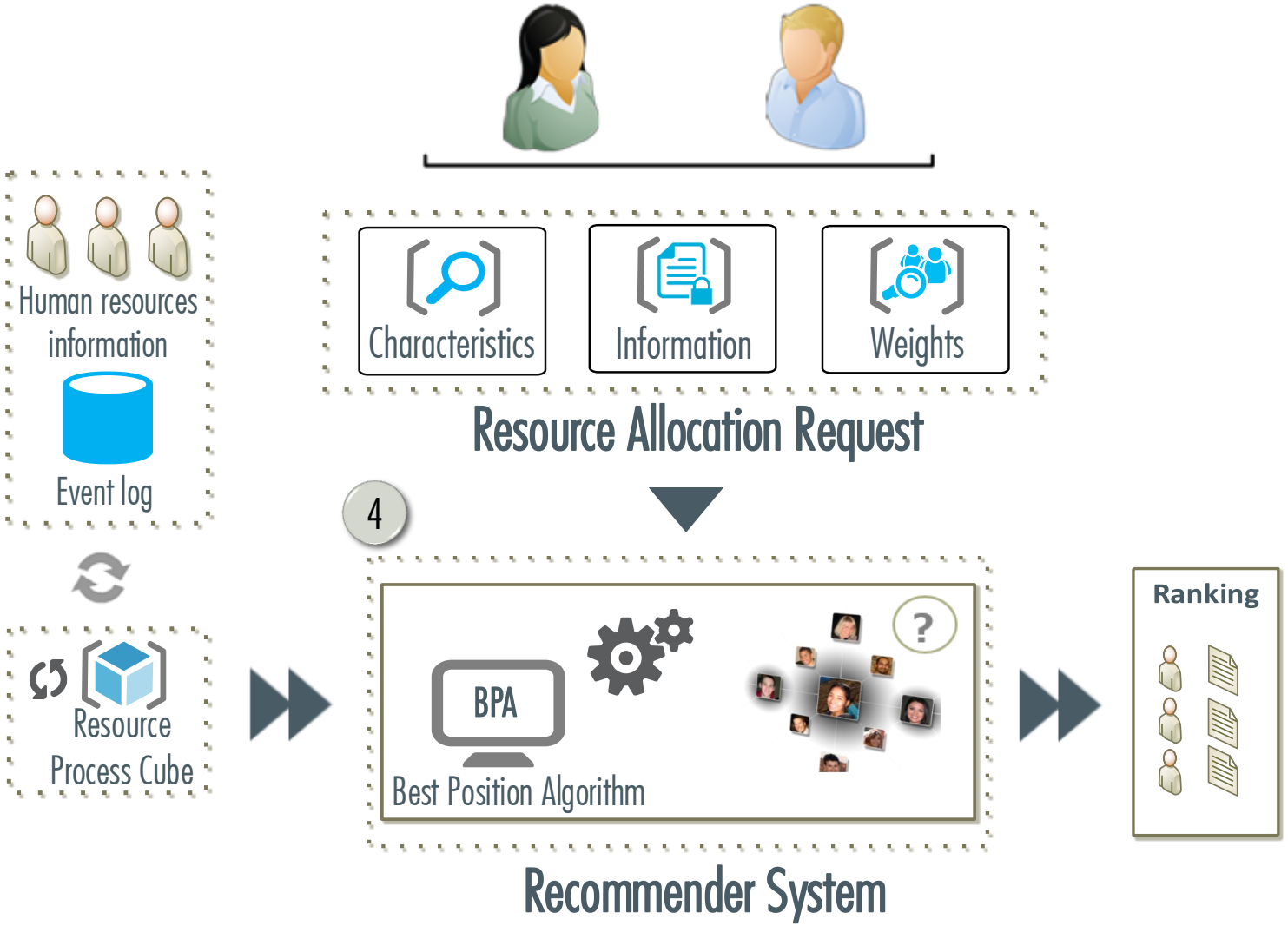
Proposed framework



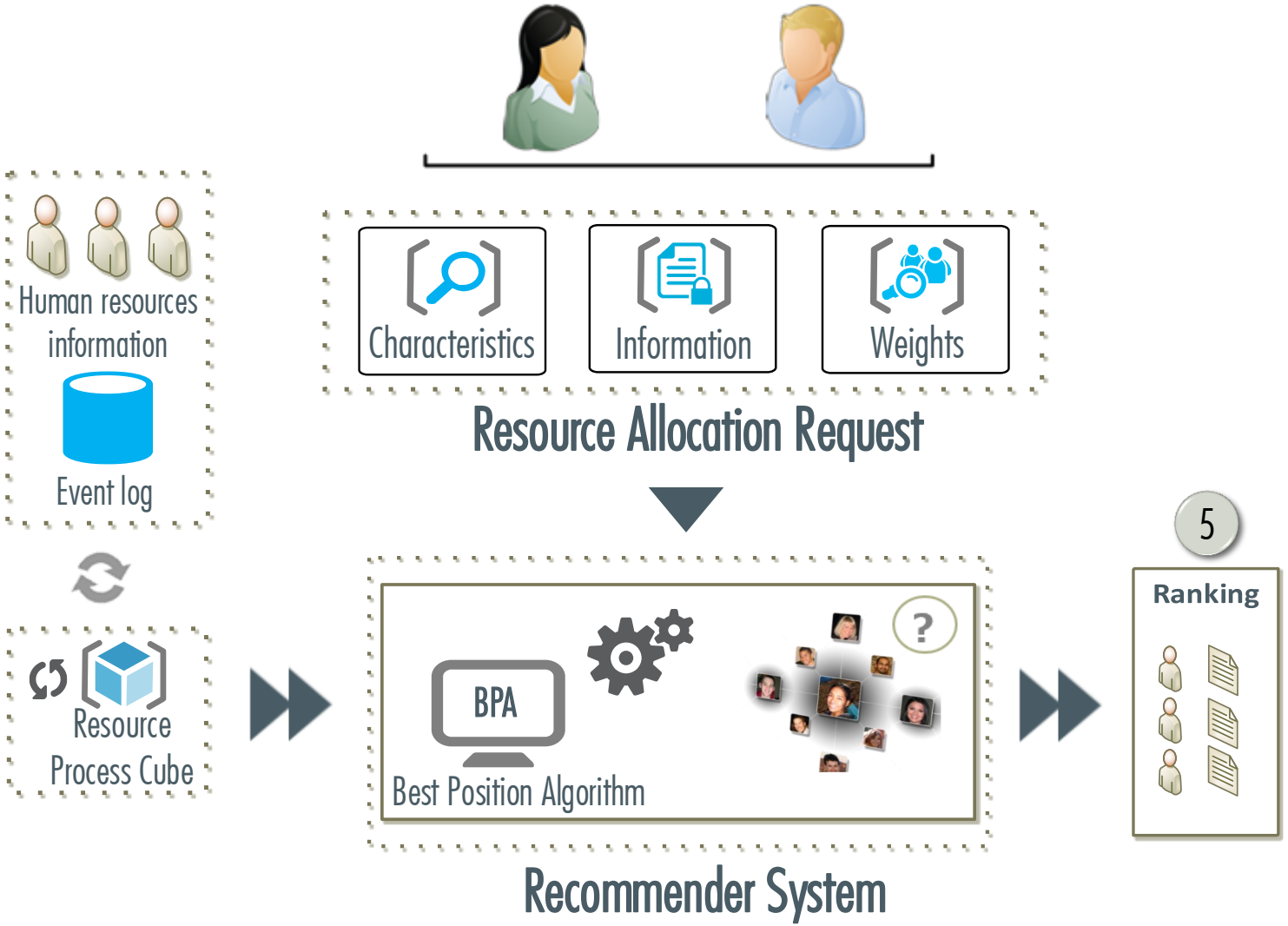
Proposed framework



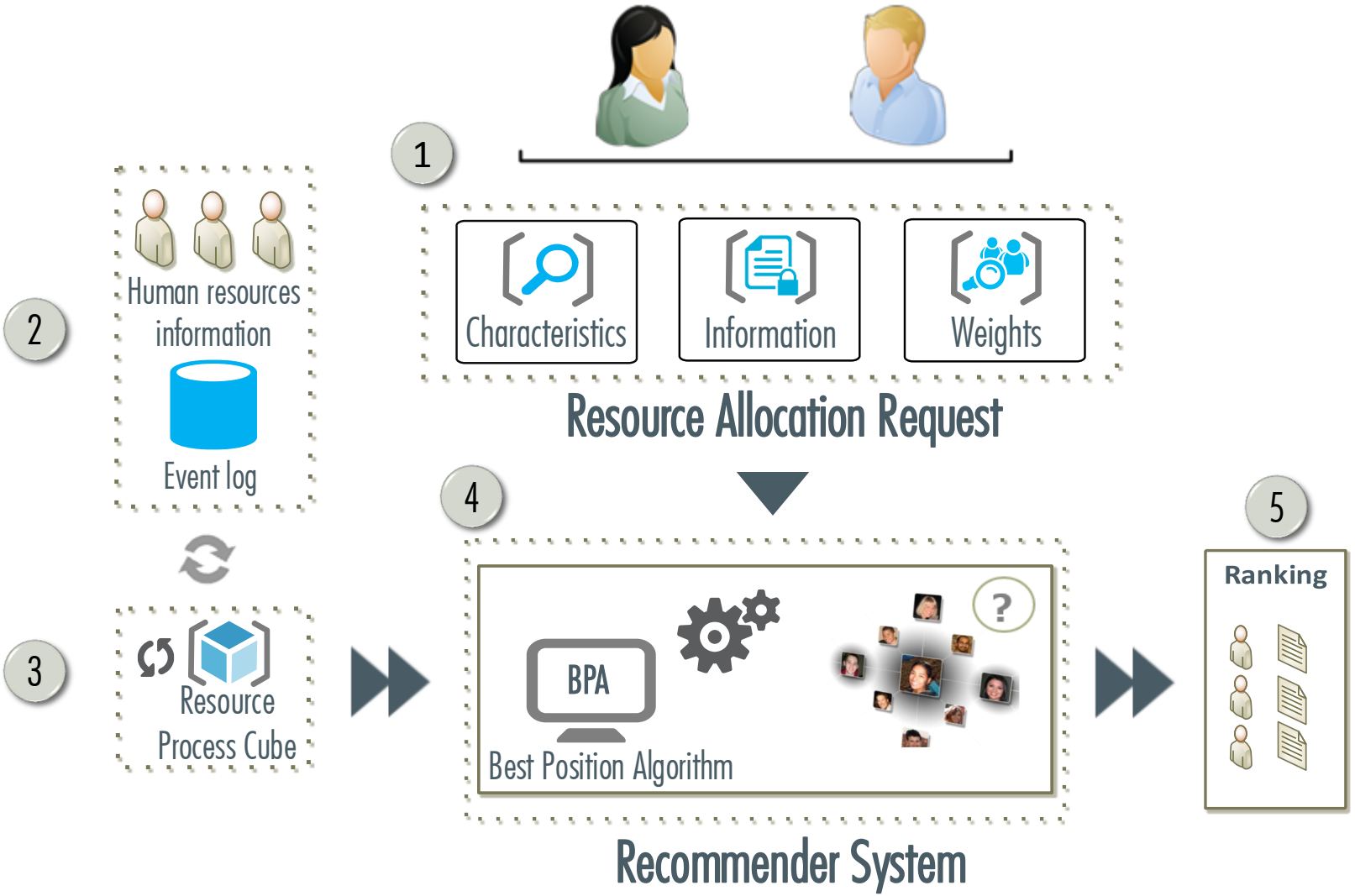
Proposed framework



Proposed framework

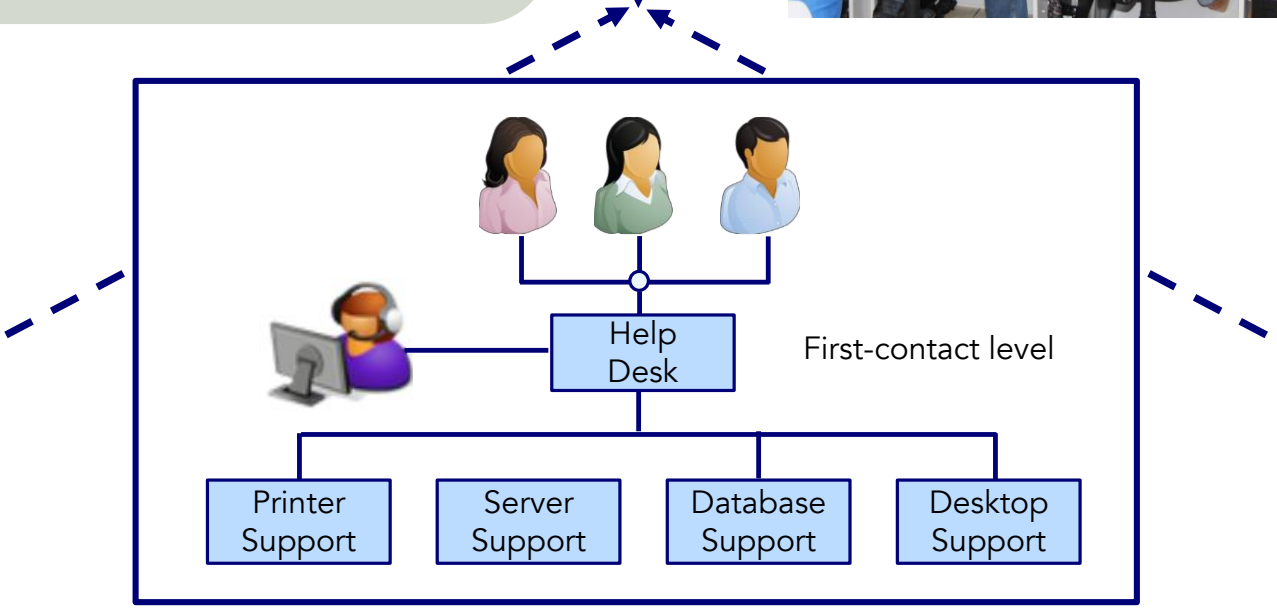


Proposed framework

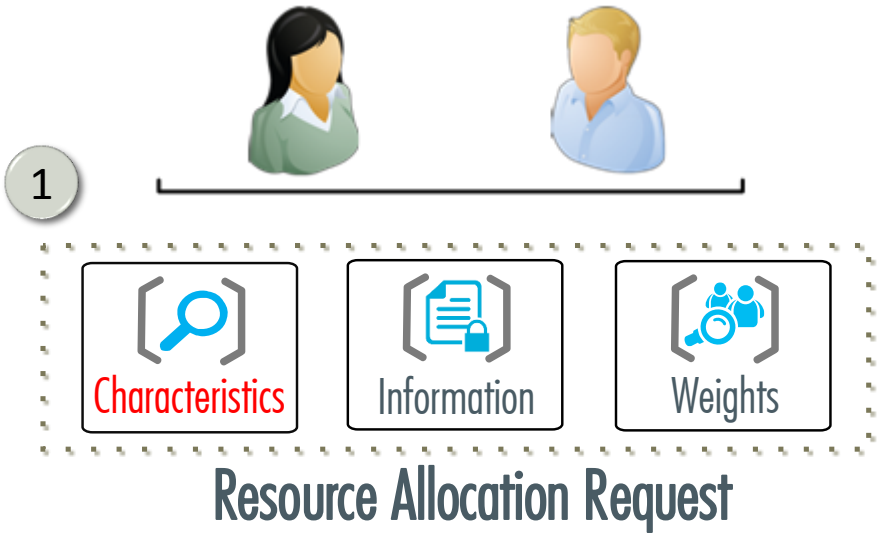


Help-Desk process

Ring...!!!
I have a issue



Resource allocation request



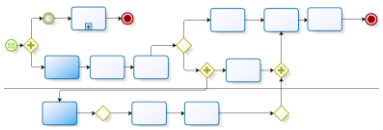
Resource allocation request

Characteristics

Characterization **C** = (f_1, …, f_n)

C = sub-process, typology

In the Help-Desk:

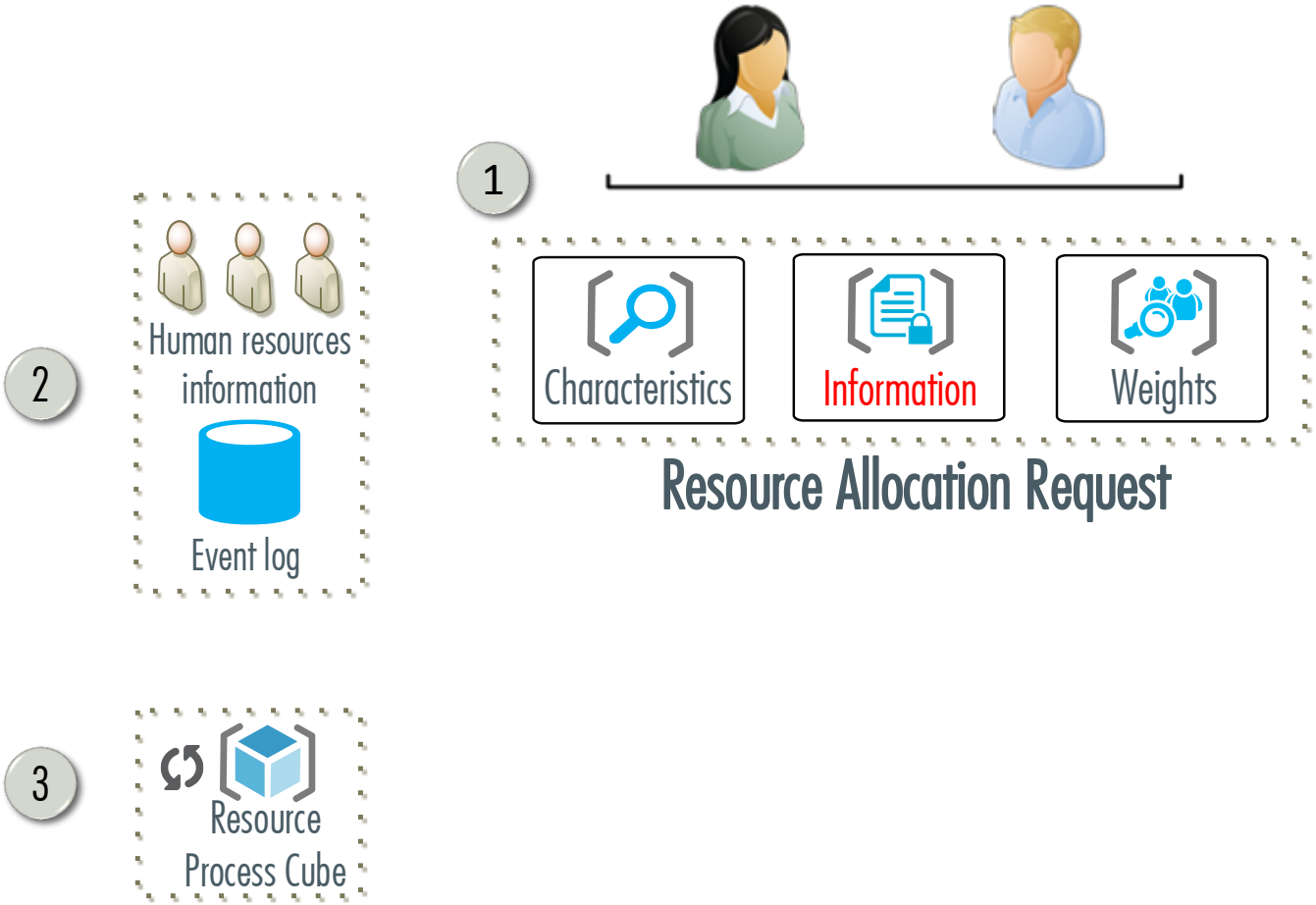


- First contact level 1
- Expert level 2

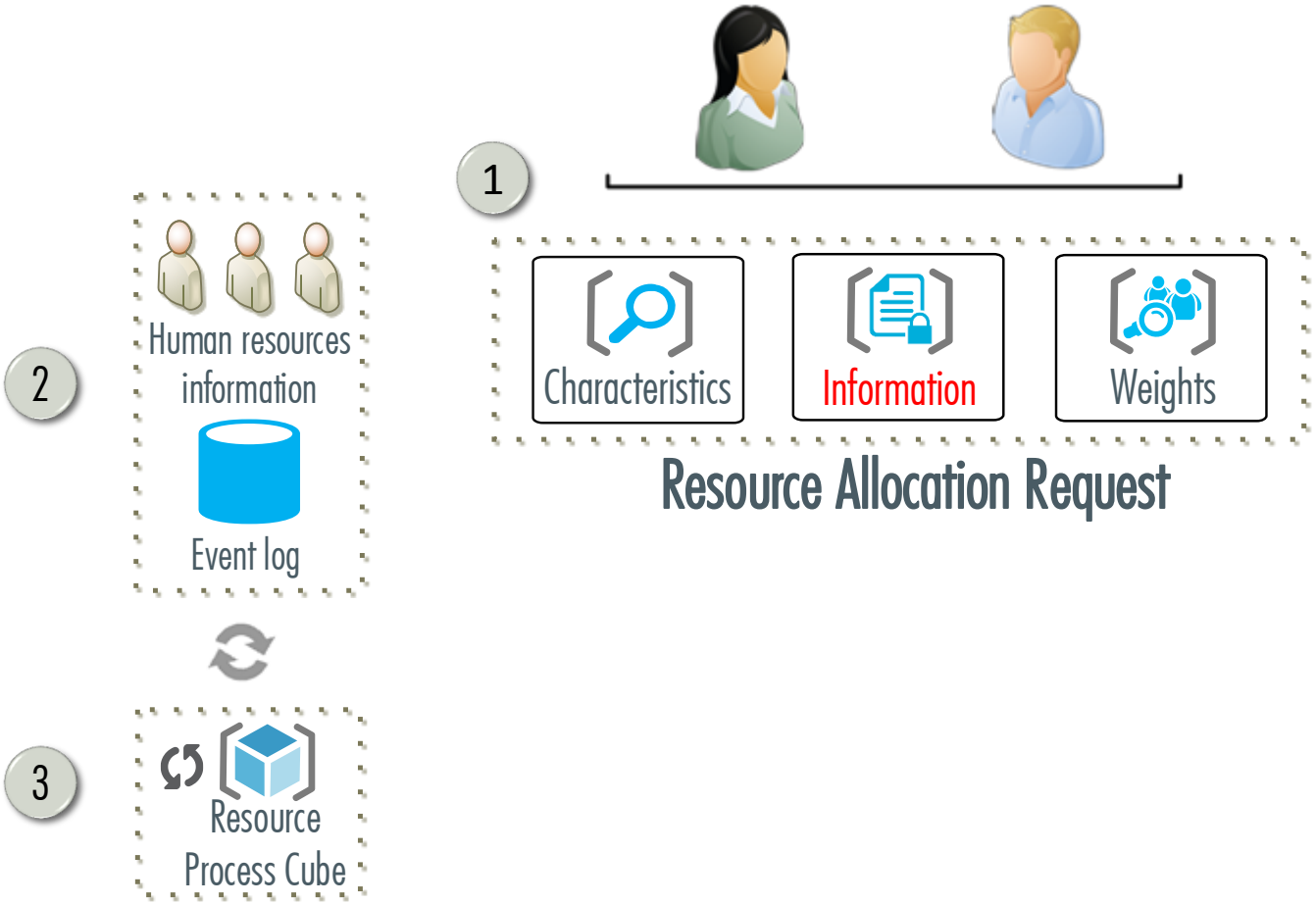
Typologies

- Printer-support
- Server-support

Resource allocation request



Resource allocation request



Resource allocation request

Information

Proposed dimensions

Expertise matrices

Dimensions (history)

- Frequency
- Performance
- Quality
- $ Cost
- Workload

Expertise Dimension

- Competencies
- Skills
- Knowledge

Required Expertise

$\mathbb{E}_C$ [1 : n]

Resource Expertise

$\mathbb{E}_r$ [1 : n]

Resource process cube ( )

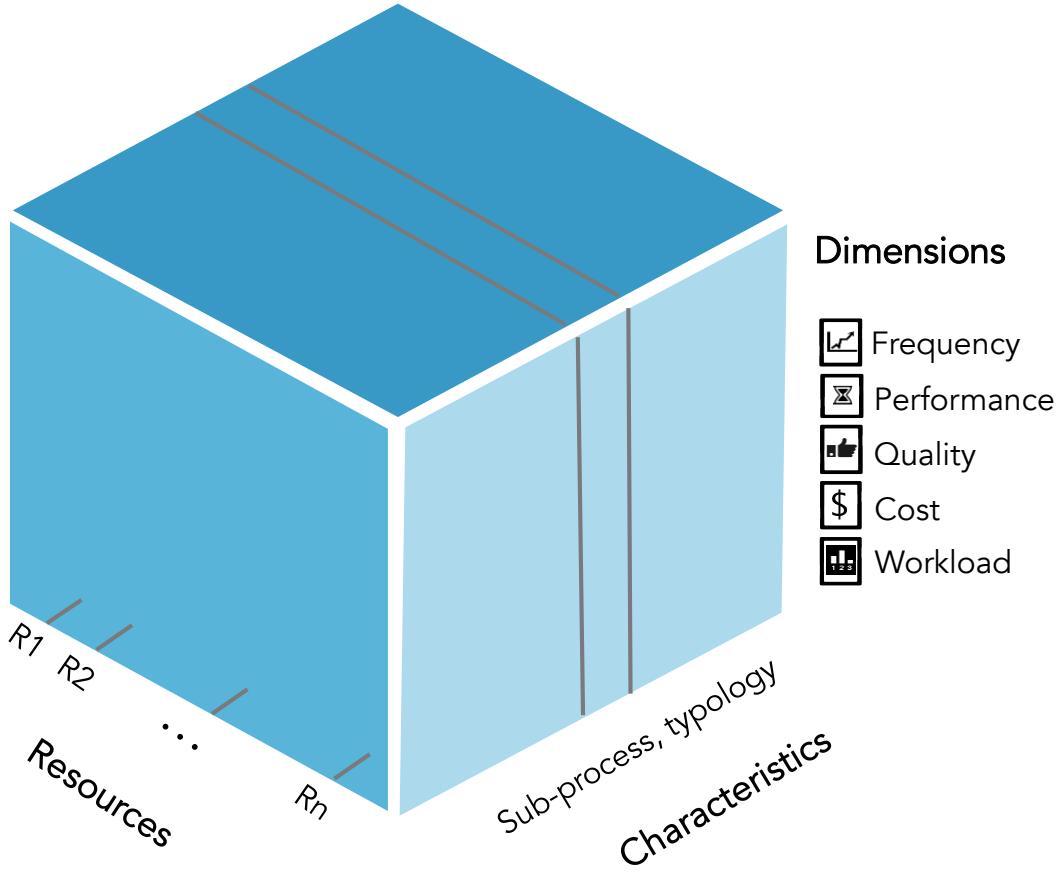
Example

C_1 = (sub-process 1, printers)

Required: $\mathbb{E}_{C_1}$ = [2,2]

Resource 1: $\mathbb{E}_{r_1}$ = [0,1]

Resource process cube (Q)



Resource allocation metrics

Prioritize the fastest resources

$$Performance\_Metric(r,c) = \frac{@[\,][c][p].max - @[r][c][p].avg}{@[\,][c][p].max - @[\,][c][p].min}$$

Resource allocation metrics

Prioritize the best evaluated resources

$$Quality\_Metric(r,c) = \frac{Q[r][c][q].avg - Q[\,][c][q].min}{Q[\,][c][q].max - Q[\,][c][q].min}$$

Resource allocation metrics

Prioritize the cheapest resources

$$\$ \; Cost\_Metric(r,c) = \frac{@[\,][c][co].max - @[r][c][co].avg}{@[\,][c][co].max - @[\,][c][co].min}$$

Resource allocation metrics

Prioritize the most idle resources

$$Workload\_Metric\,(r,c) = \frac{Q[r][\,][w].top - Q[r][\,][w].total}{Q[r][\,][w].top - Q[r][\,][w].bottom}$$

Resource allocation metrics

Prioritize the most experienced resources

$$Frequency\_Metric(r,c) = \frac{\text{logarithm}\,(@[r][c][f].\text{total}) + 1}{\text{logarithm}\,(@[\,][c][f].\text{total}) + 1}$$

Resource allocation metrics

Identify how below the resource is from the desired expertise level

$$underQualification\_Metric = 1 - \frac{1}{n}\sqrt{\sum_{i=1}^{n}(under(i))^2}$$

$$under(i) = \begin{cases} \frac{\mathbb{E}_c[i] - \mathbb{E}_r[i]}{\mathbb{E}_c[i] - \perp_i} & \text{if } \mathbb{E}_c[i] >= \mathbb{E}_r[i] \\ 0 & \text{otherwise} \end{cases}$$

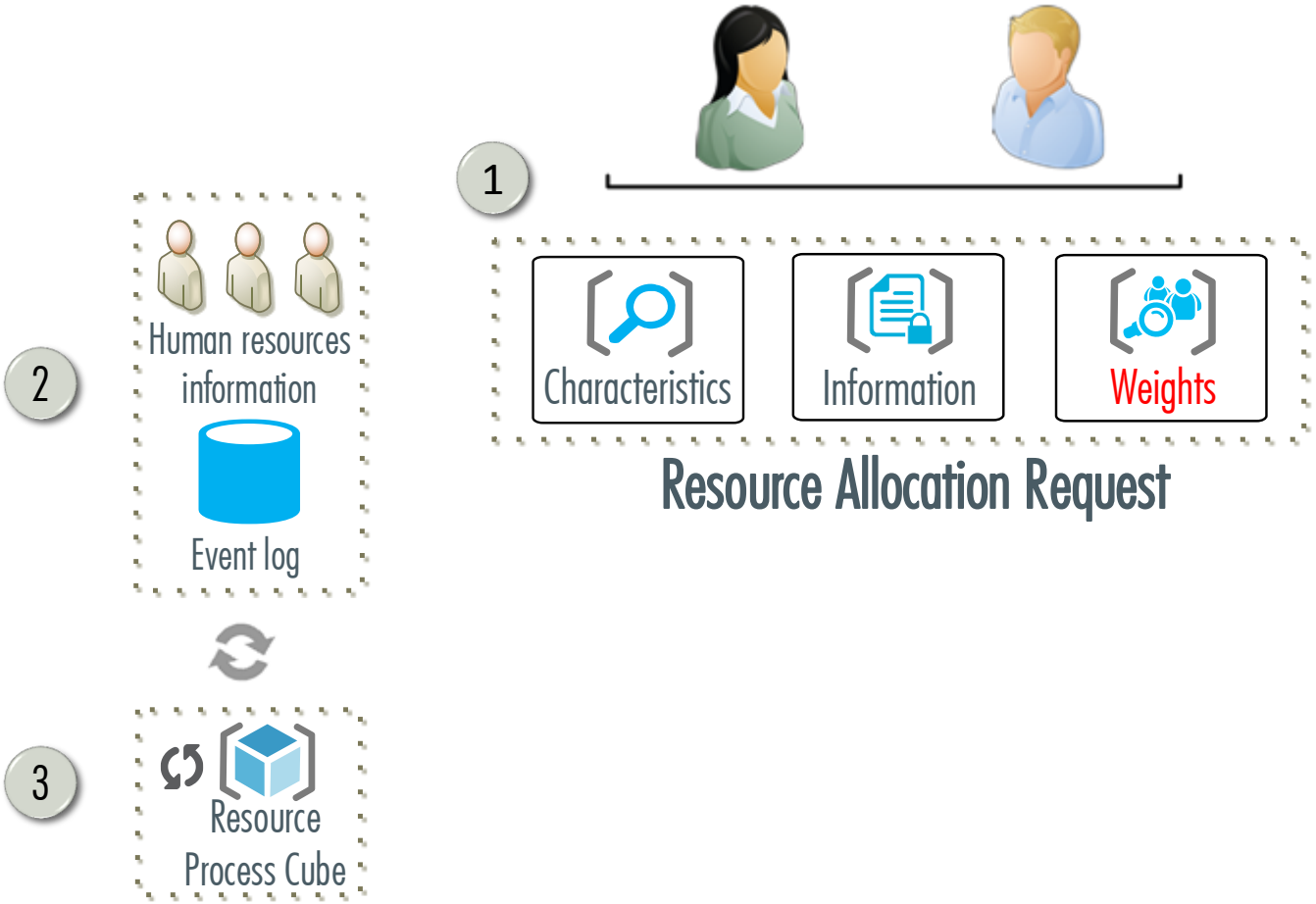
Resource allocation metrics

Identify how above the resource is from the desired expertise level

$$overQualification\_Metric = 1 - \frac{1}{n}\sqrt{\sum_{i=1}^{n}(over(i))^2}$$

$$over(i) = \begin{cases} \frac{\mathbb{E}_r[i] - \mathbb{E}_c[i]}{T_i - \mathbb{E}_c[i]} & \text{if } \mathbb{E}_r[i] >= \mathbb{E}_c[i] \\ 0 & \text{otherwise} \end{cases}$$

Resource allocation request



Resource allocation request

Weights

Describe the importance of each dimension

Large size company:

F:010 P:050

Q:010 C:100

U:015 O:000

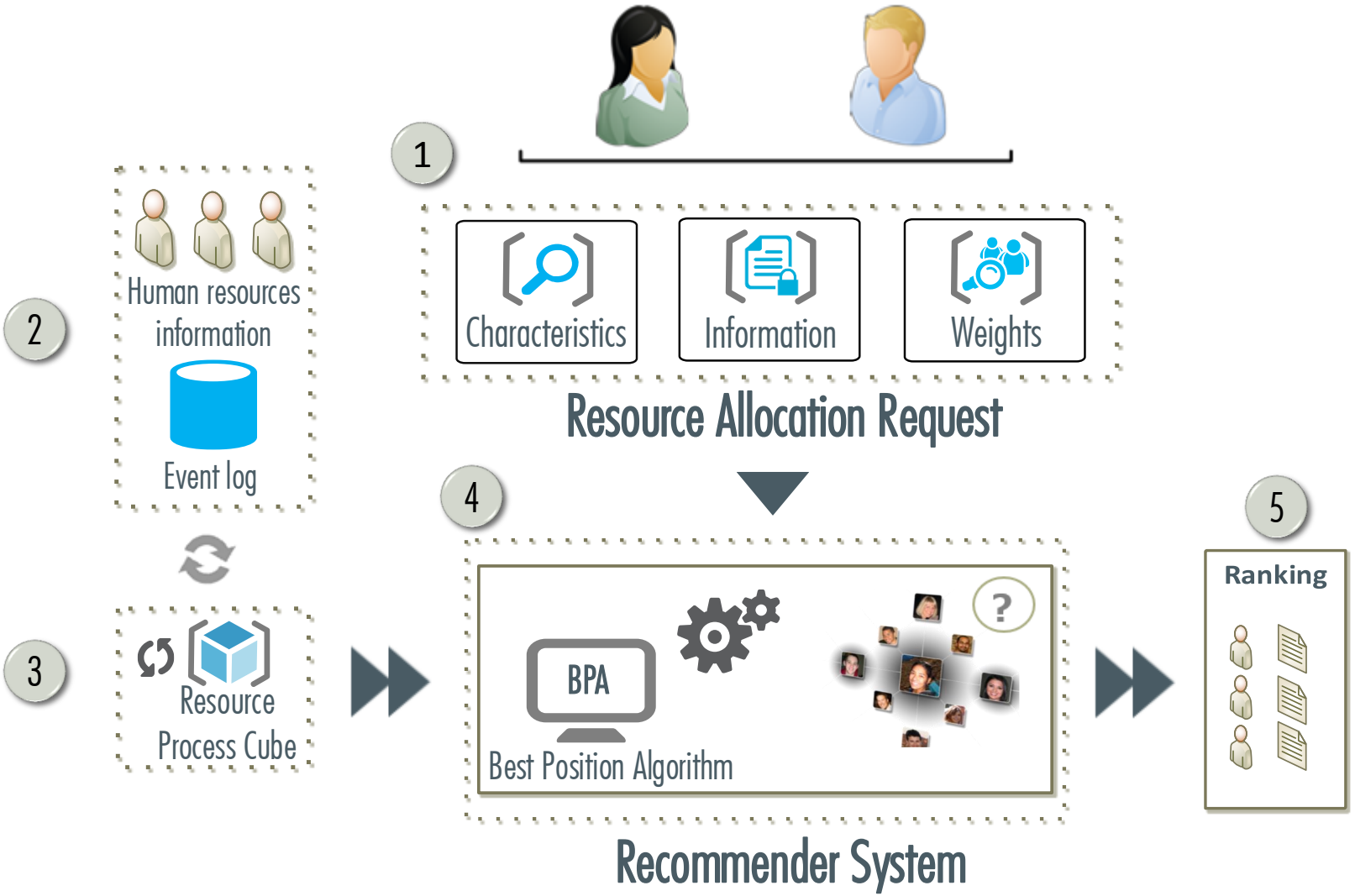
Small size company:

F:025 P:015

Q:100 C:030

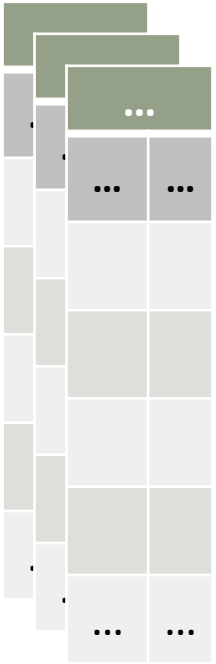
U:075 O:065

Proposed framework



Implementation with BPA [10]

Position	Frequency		Performance		Quality	
	Data Item	Local Score	Data Item	Local Score	Data Item	Local Score
1	R6	0.601	R3	0.851	R9	0.913
2	R4	0.593	R2	0.833	R7	0.864
3	R5	0.554	R1	0.832	R8	0.808
4	R1	0.525	R5	0.775	R2	0.723
...	...	...	...	...	...	...



Overall top	
Data item	Score
R1	0.795
R2	0.788
R14	0.784

[10] Akbarinia, R., Pacitti, E., Valduriez, P.: Best position algorithms for ecient top-k query processing, 2011

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Experimental evaluation

Future work

Conclusions

Experimental evaluation

Help-Desk process

Preliminary evaluation

Case attributes	Case ID, Sub-process group, Process typology Resource, Cost, Customer satisfaction (quality) Creation date, Closing date, Priority
Experiment 1	Calculate the top 3-queries processing over the sorted lists, considering each single metric by itself.
Experiment 2	3 types of companies: large size, mid size, and small size
Experiment 3	Different event log sizes and the amount of resources were increased

Experiments results

Experiment 1

Top 3-queries
Single metric

Exp.	Weights (%)	# Cases	#R SP1	#R SP2	Ranking	Time (sec)
1.1	F:100 - others:0	1200	20	20	R06: 0.601 - R04: 0.593 - R05: 0.554	0.954
1.2	P:100 - others:0	1200	20	20	R03: 0.851 - R02: 0.833 - R01: 0.832	0.954
1.3	Q:100 - others:0	1200	20	20	R09: 0.913 - R07: 0.864 - R08: 0.808	0.954
1.4	C:100 - others:0	1200	20	20	R18: 0.962 - R20: 0.962 - R19: 0.959	0.954
1.5	U:100 - O:100 - others:0	1200	20	20	R12: 1.000 - R13: 1.000 - R14: 1.000	0.954
2.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	20	20	R20: 0.647 - R03: 0.635 - R18: 0.632	11.122
2.2	F:025 - P:015 - Q:100 C:030 - U:075 - O:065	1200	20	20	R19: 0.802 - R14: 0.758 - R13: 0.754	11.565
2.3	F:050 - P:050 - Q:050 C:050 - U:050 - O:050	1200	20	20	R19: 0.725 - R03: 0.712 - R02: 0.675	10.897
3.1.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	14	14	R01: 0.795 - R02: 0.788 - R14: 0.784	10.942
3.1.2	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	10000	14	14	R13: 0.769 - R02: 0.567 - R14: 0.758	17.160
3.1.3	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	100000	14	14	R13: 0.767 - R14: 0.765 - R02: 0.764	59.063
3.2.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	20	20	R19: 0.649 - R20: 0.647 - R03: 0.635	11.122
3.2.2	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	10000	20	20	R01: 0.586 - R03: 0.582 - R02: 0.573	17.642
3.2.3	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	100000	20	20	R01: 0.834 - R20: 0.784 - R18: 0.783	58.913
3.3.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	35	35	R03: 0.626 - R05: 0.618 - R04: 0.572	11.014
3.3.2	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	10000	35	35	R04: 0.608 - R05: 0.603 - R01: 0.599	17.739
3.3.3	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	100000	35	35	R04: 0.593 - R02: 0.580 - R11: 0.428	58.637

Experiments results

Experiment 2

Top 3-queries
3 help desk companies

Exp.	Weights (%)	# Cases	#R SP1	#R SP2	Ranking	Time (sec)
1.1	F:100 - others:0	1200	20	20	R06: 0.601 - R04: 0.593 - R05: 0.554	0.954
1.2	P:100 - others:0	1200	20	20	R03: 0.851 - R02: 0.833 - R01: 0.832	0.954
1.3	Q:100 - others:0	1200	20	20	R09: 0.913 - R07: 0.864 - R08: 0.808	0.954
1.4	C:100 - others:0	1200	20	20	R18: 0.962 - R20: 0.962 - R19: 0.959	0.954
1.5	U:100 - O:100 - others:0	1200	20	20	R12: 1.000 - R13: 1.000 - R14: 1.000	0.954
2.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000 ☑	1200	20	20	R20: 0.647 - R03: 0.635 - R18: 0.632	11.122
2.2	F:025 - P:015 - Q:100 C:030 - U:075 - O:065 ☑	1200	20	20	R19: 0.802 - R14: 0.758 - R13: 0.754	11.565
2.3	F:050 - P:050 - Q:050 C:050 - U:050 - O:050 ☑	1200	20	20	R19: 0.725 - R03: 0.712 - R02: 0.675	10.897
3.1.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	14	14	R01: 0.795 - R02: 0.788 - R14: 0.784	10.942
3.1.2	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	10000	14	14	R13: 0.769 - R02: 0.567 - R14: 0.758	17.160
3.1.3	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	100000	14	14	R13: 0.767 - R14: 0.765 - R02: 0.764	59.063
3.2.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	20	20	R19: 0.649 - R20: 0.647 - R03: 0.635	11.122
3.2.2	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	10000	20	20	R01: 0.586 - R03: 0.582 - R02: 0.573	17.642
3.2.3	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	100000	20	20	R01: 0.834 - R20: 0.784 - R18: 0.783	58.913
3.3.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	35	35	R03: 0.626 - R05: 0.618 - R04: 0.572	11.014
3.3.2	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	10000	35	35	R04: 0.608 - R05: 0.603 - R01: 0.599	17.739
3.3.3	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	100000	35	35	R04: 0.593 - R02: 0.580 - R11: 0.428	58.637

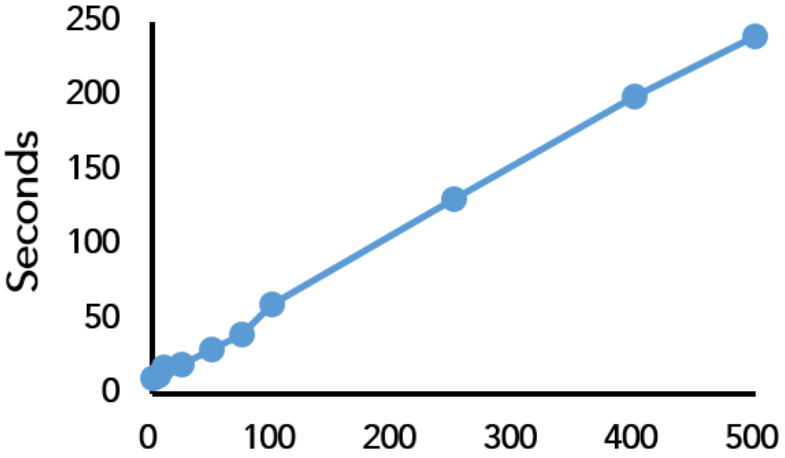
Experiments results

Experiment 3

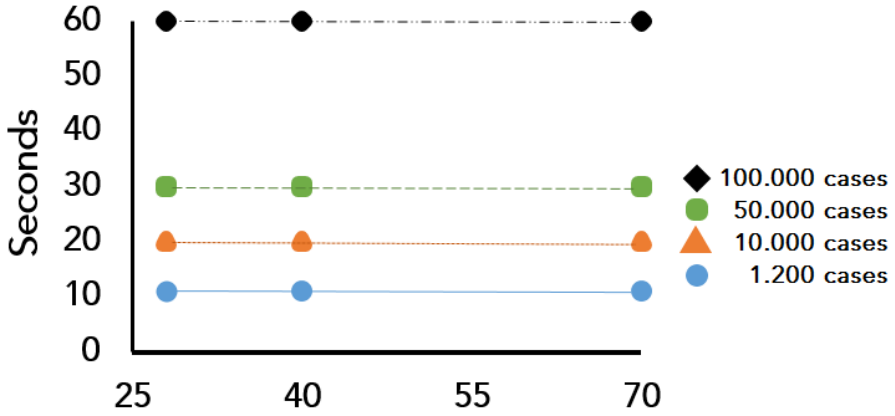
Top 3-queries
3 help desk companies
Log size
Amount of resources

Exp.	Weights (%)	# Cases	#R SP1	#R SP2	Ranking	Time (sec)
1.1	F:100 - others:0	1200	20	20	R06: 0.601 - R04: 0.593 - R05: 0.554	0.954
1.2	P:100 - others:0	1200	20	20	R03: 0.851 - R02: 0.833 - R01: 0.832	0.954
1.3	Q:100 - others:0	1200	20	20	R09: 0.913 - R07: 0.864 - R08: 0.808	0.954
1.4	C:100 - others:0	1200	20	20	R18: 0.962 - R20: 0.962 - R19: 0.959	0.954
1.5	U:100 - O:100 - others:0	1200	20	20	R12: 1.000 - R13: 1.000 - R14: 1.000	0.954
2.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	20	20	R20: 0.647 - R03: 0.635 - R18: 0.632	11.122
2.2	F:025 - P:015 - Q:100 C:030 - U:075 - O:065	1200	20	20	R19: 0.802 - R14: 0.758 - R13: 0.754	11.565
2.3	F:050 - P:050 - Q:050 C:050 - U:050 - O:050	1200	20	20	R19: 0.725 - R03: 0.712 - R02: 0.675	10.897
3.1.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	14	14	R01: 0.795 - R02: 0.788 - R14: 0.784	10.942
3.1.2	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	10000	14	14	R13: 0.769 - R02: 0.567 - R14: 0.758	17.160
3.1.3	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	100000	14	14	R13: 0.767 - R14: 0.765 - R02: 0.764	59.063
3.2.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	20	20	R19: 0.649 - R20: 0.647 - R03: 0.635	11.122
3.2.2	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	10000	20	20	R01: 0.586 - R03: 0.582 - R02: 0.573	17.642
3.2.3	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	100000	20	20	R01: 0.834 - R20: 0.784 - R18: 0.783	58.913
3.3.1	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	1200	35	35	R03: 0.626 - R05: 0.618 - R04: 0.572	11.014
3.3.2	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	10000	35	35	R04: 0.608 - R05: 0.603 - R01: 0.599	17.739
3.3.3	F:010 - P:050 - Q:010 C:100 - U:015 - O:000	100000	35	35	R04: 0.593 - R02: 0.580 - R11: 0.428	58.637

Experiments results



(a) Number of cases (thousands)



(b) Number of resources

Performance analysis

Outline

Introduction

Approach

- General approach
- Resource allocation request
- Resource process cube and allocation metrics
- Implementation

Experimental evaluation

Future work

Conclusions

Future work

Explore potential application domains

Case studies using real data

Incorporate new dimensions

Combine our approach with existing works

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Conclusions

Consider different perspectives

New allocation technique

Multi – factor criteria

Sub-process level

Fine-grained, generic, & extensible

BPA allows obtain a final ranking

Experimental evaluation

Synthetic data

THANK YOU FOR YOUR ATTENTION

A Framework for Recommending Resource Allocation Based on Process Mining

MICHAEL ARIAS

ERIC ROJAS

JORGE MUNOZ-GAMA

MARCOS SEPÚLVEDA