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A model framework for optimising multi-period cross-functional team selection in terms of anticipated performance

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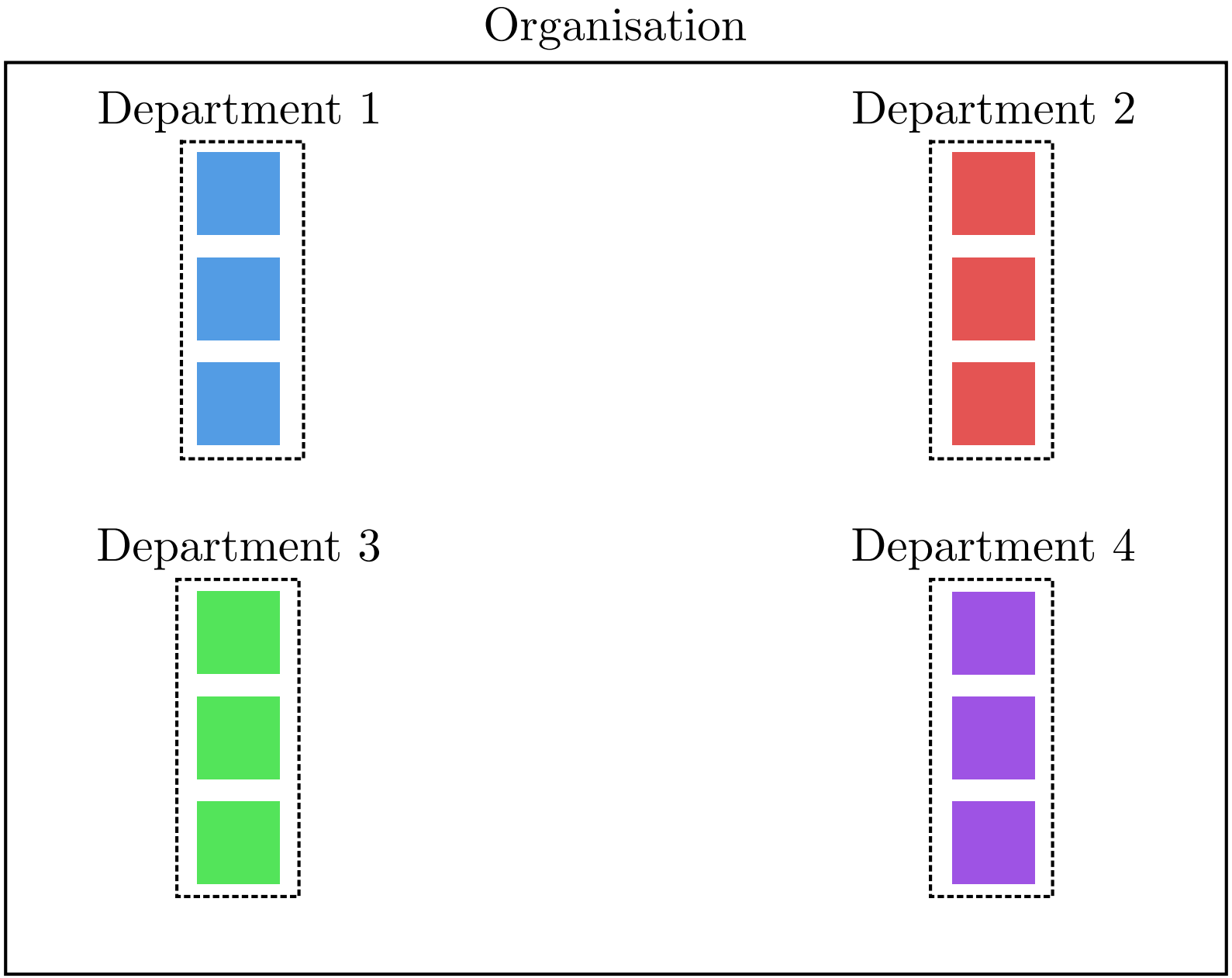
06 December 2022

Introduction



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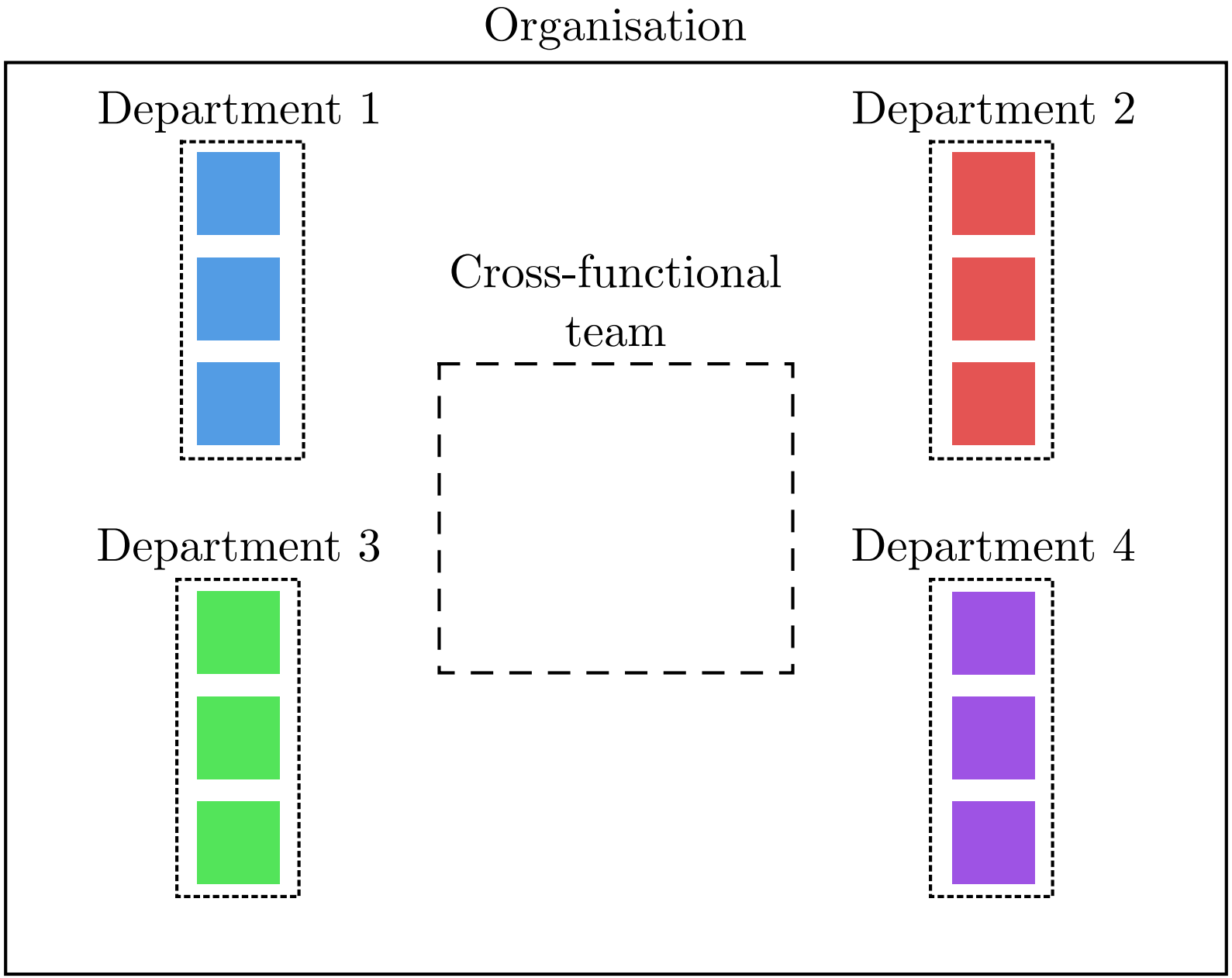

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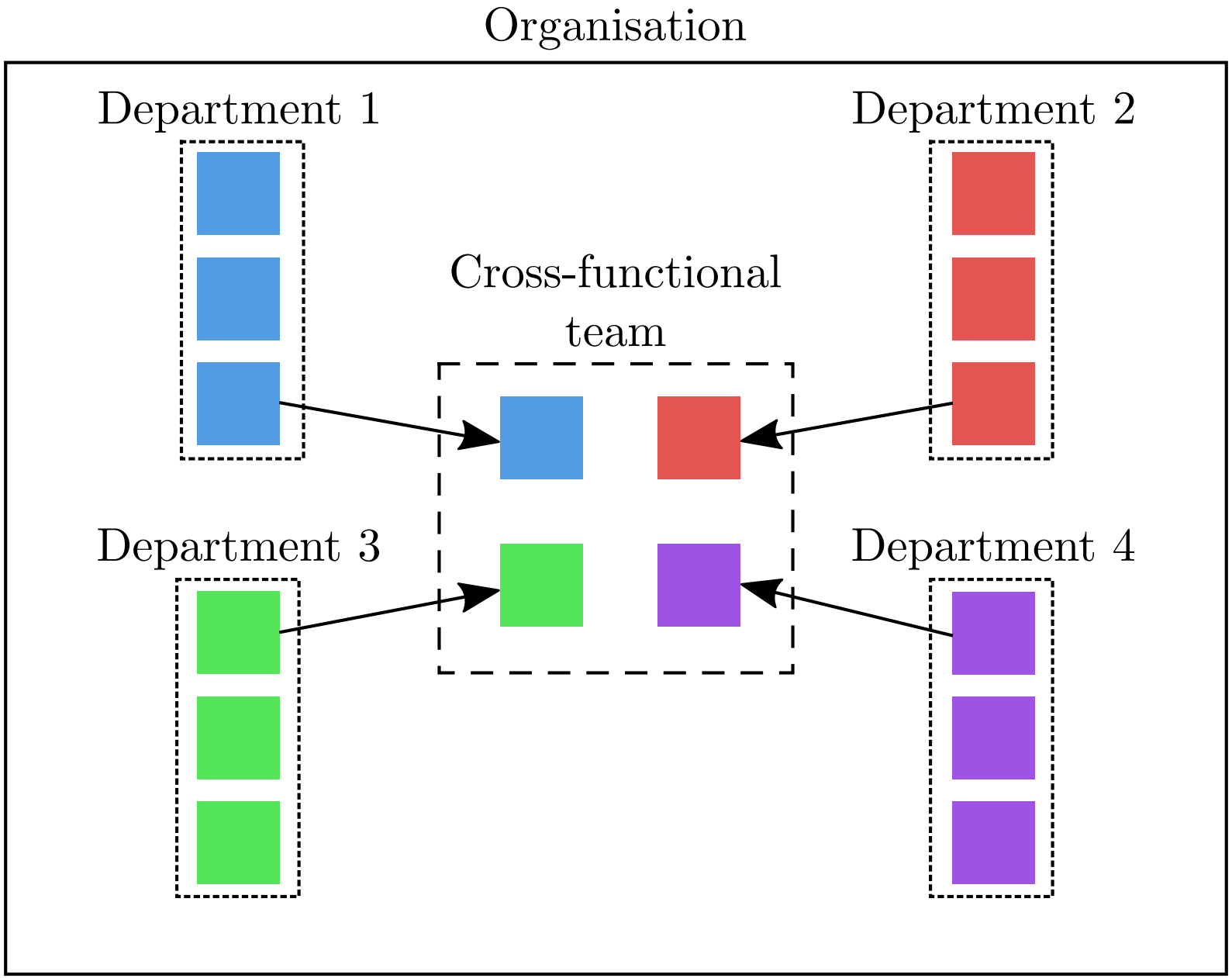

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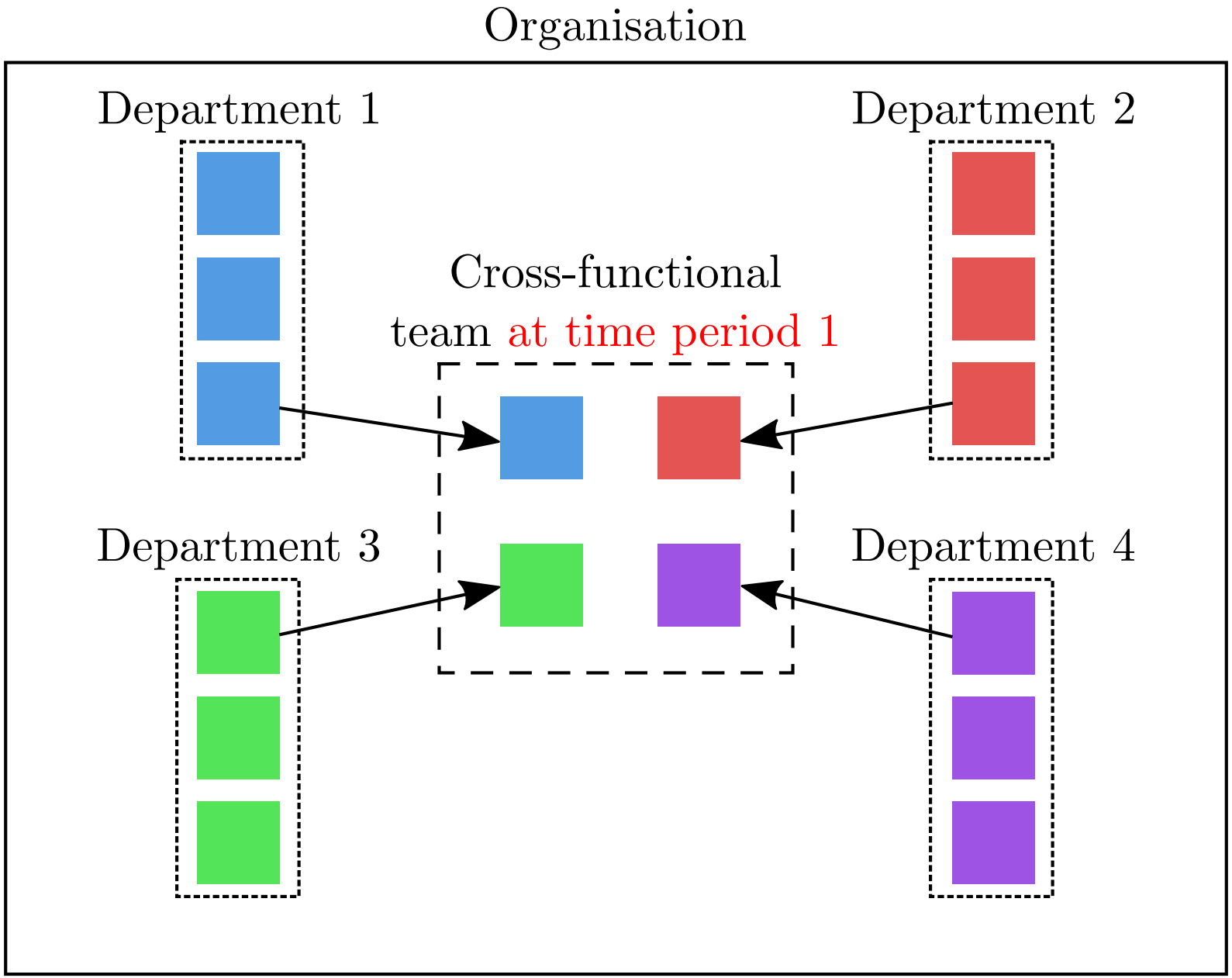

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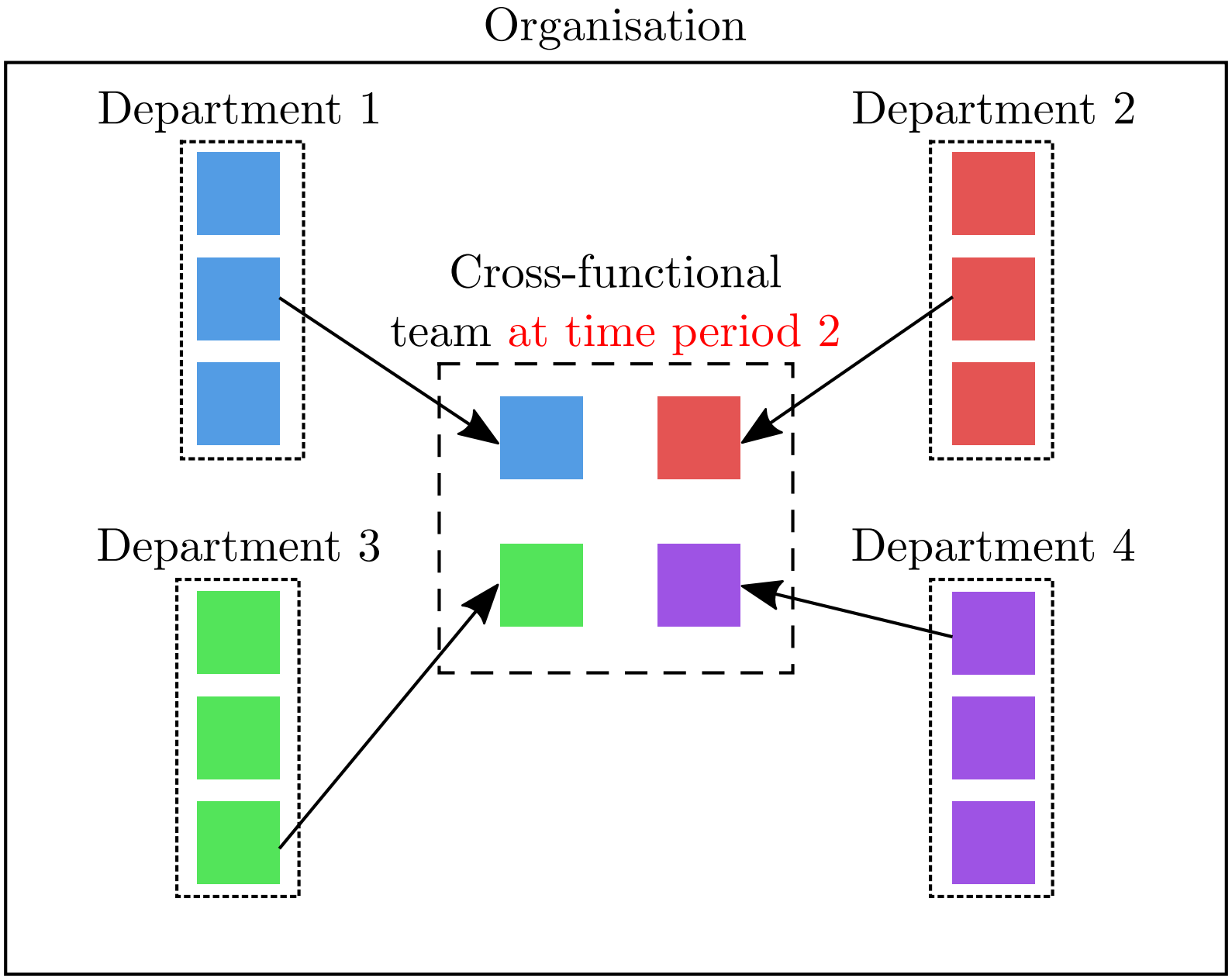

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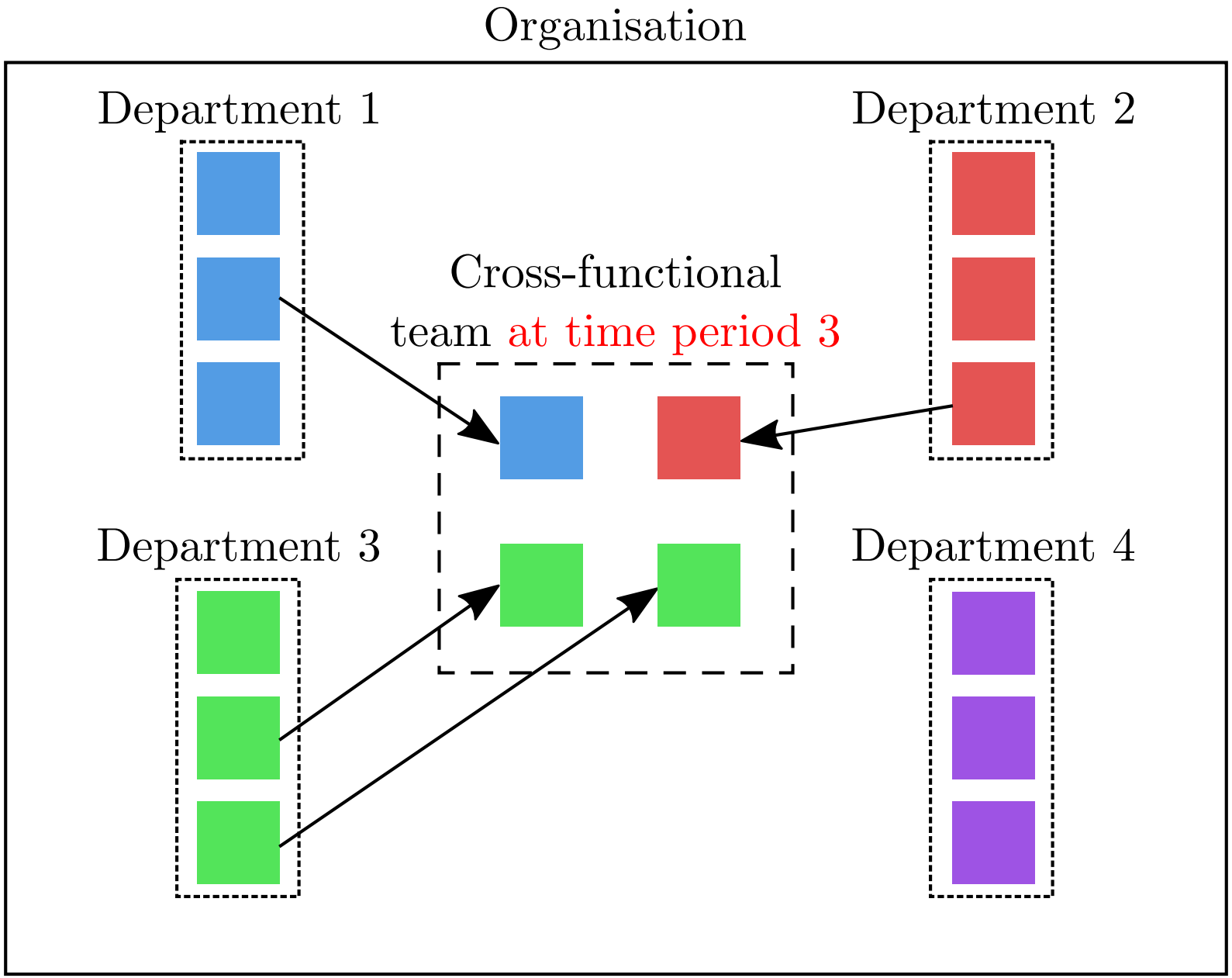

Overview

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- Background

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- Background
- Research aim

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- MCTS Framework
  Multi-period Cross-functional Team Selection framework

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- Case study

Background

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5. exhibit interdependence with respect to work flow, goals, and outcomes,
6. have different roles and responsibilities, and
7. are together embedded in an encompassing organisational system.

Background

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  - expand organisational boundaries
  - improve timing of technology developments

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- CFTs are employed to improve:
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  - improve timing of technology developments
- Often assigned to complete tasks which require input and expertise of individuals from various departments in an organisation [1].

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- Success of project is dependent upon people included in the project team
- Project team selection is a complex problem in which decision makers evaluate attributes of candidates and whether they are suitable candidates to be included in the team
- The right mix of *knowledge, skills, abilities, and other characteristics* (KSAOs) of team members contributes significantly to a team's performance.

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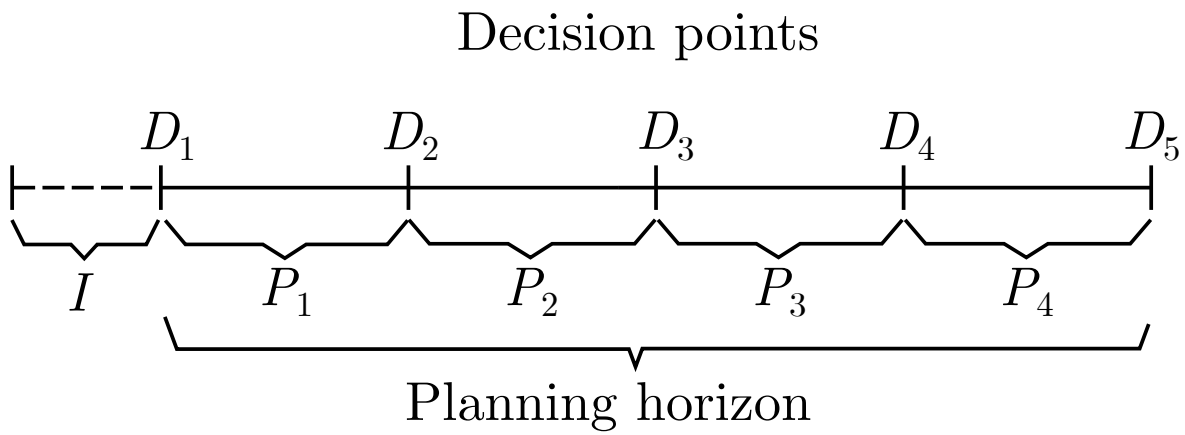
- Being able to predict the performance of available candidates in advance, may therefore prove valuable.



Research aim

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Design and demonstrate the application of a generic MCTS framework

1. Input historical performance data
2. Forecast future performance
3. Recommend high-quality CFTSs

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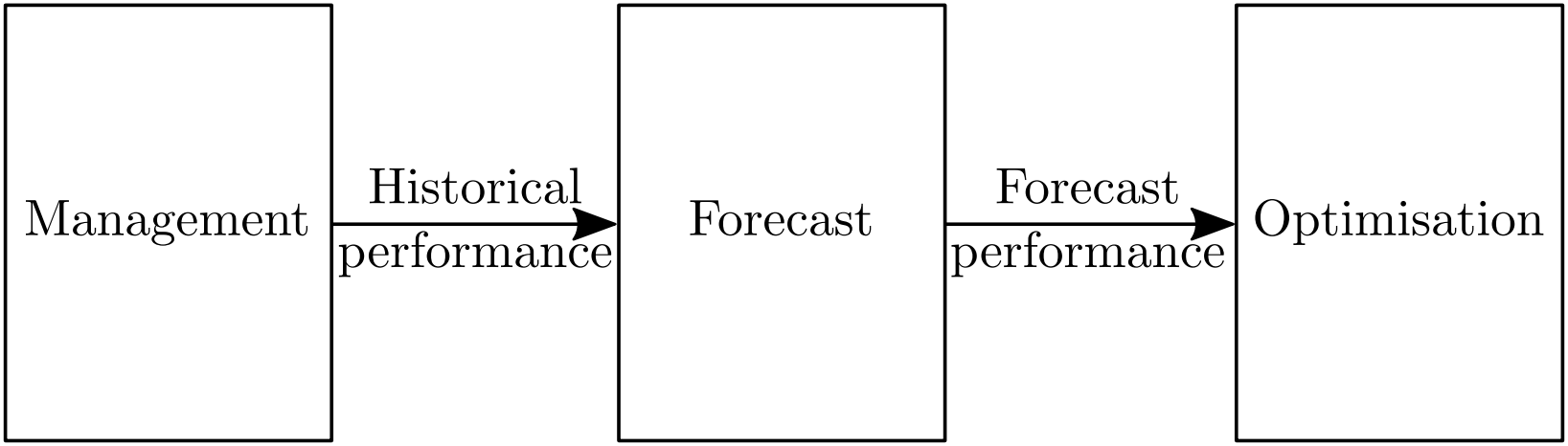
Research aim (2)

Apply the MCTS framework designed in pursuit of the first research aim to a proof-of-concept case study.

Framework design

Framework design



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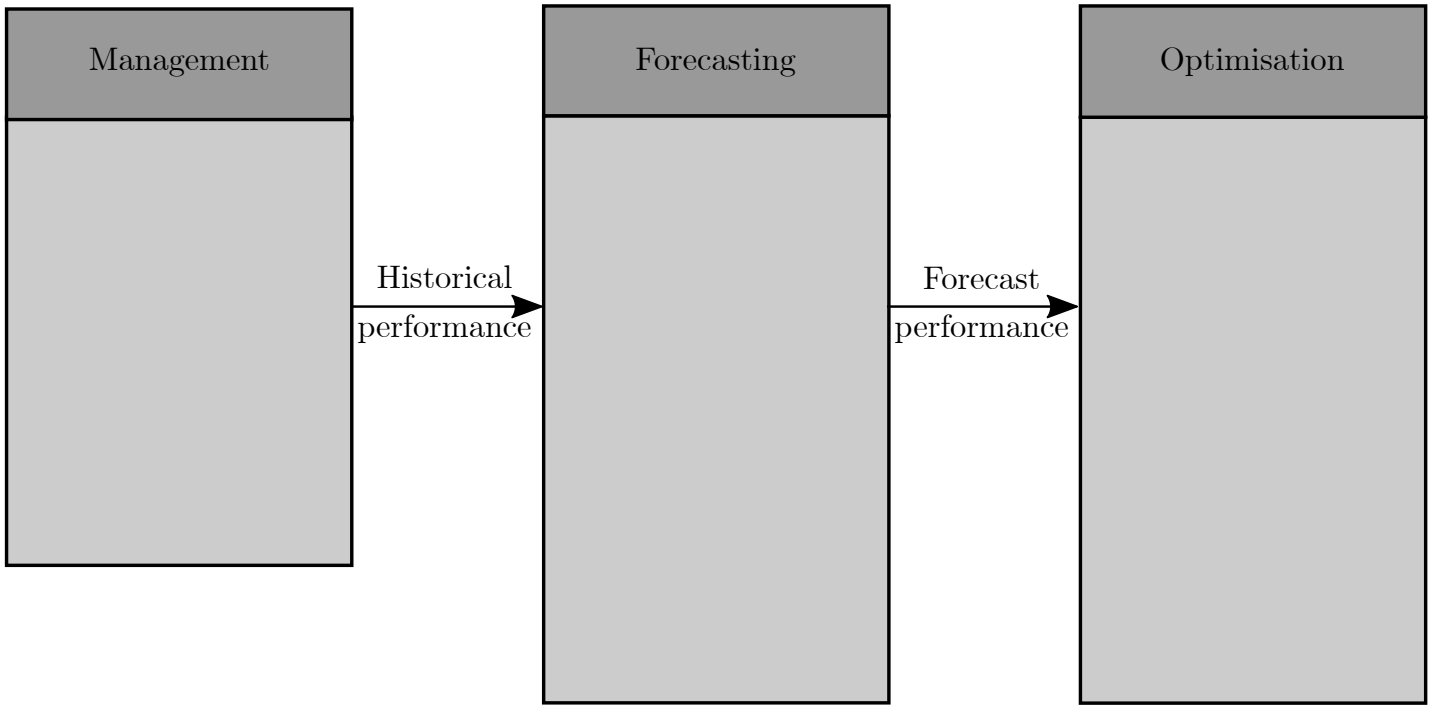

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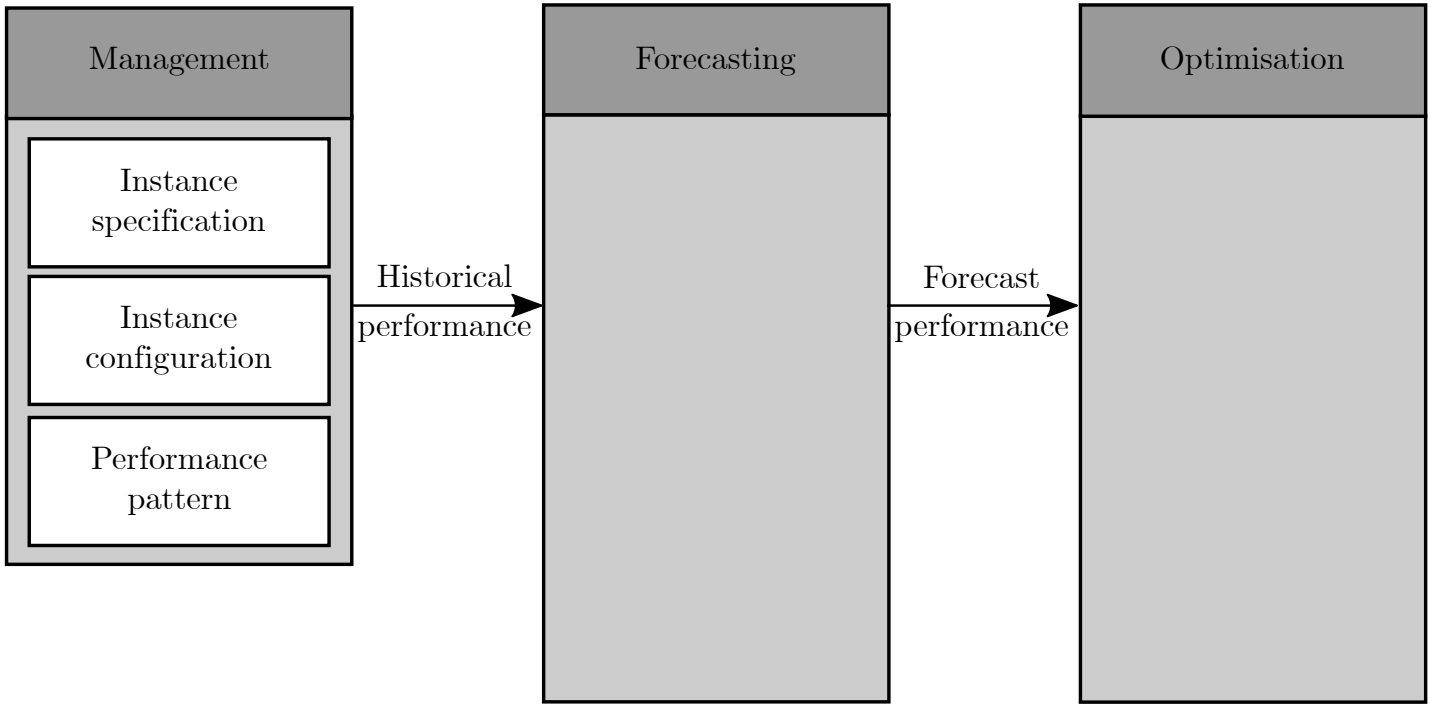
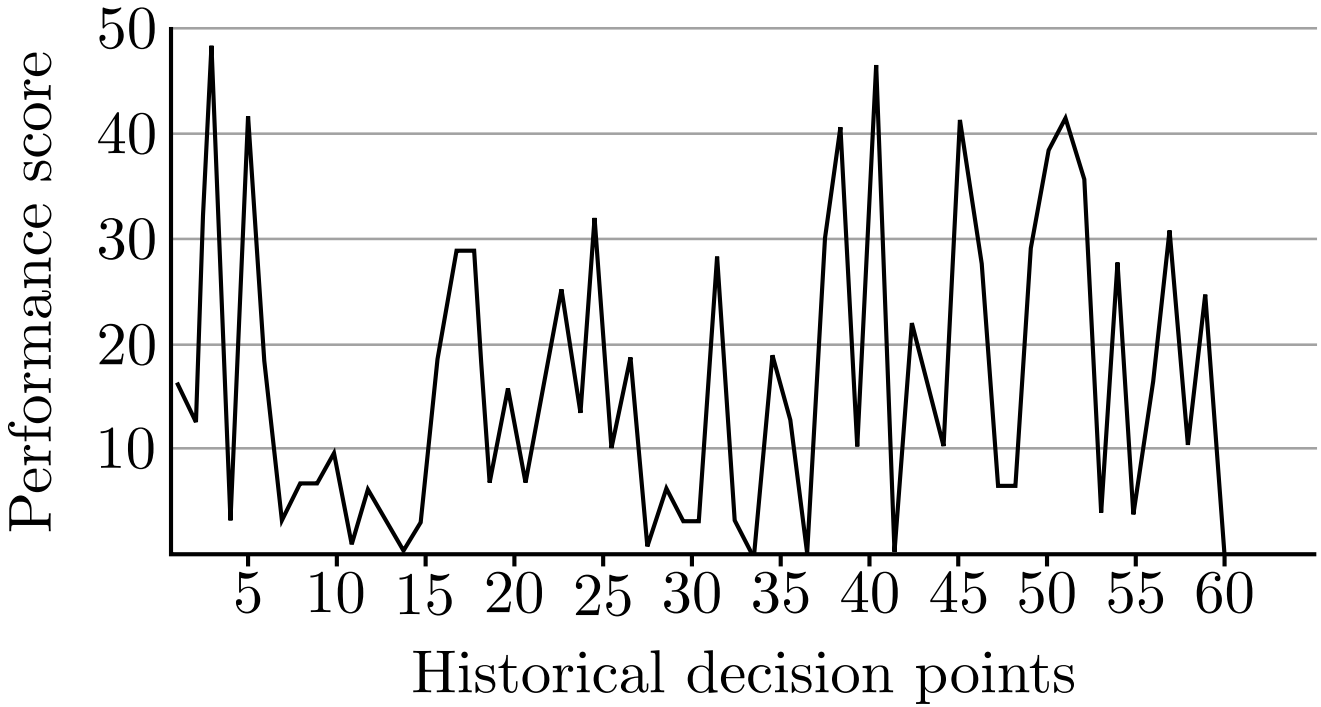


Performance pattern



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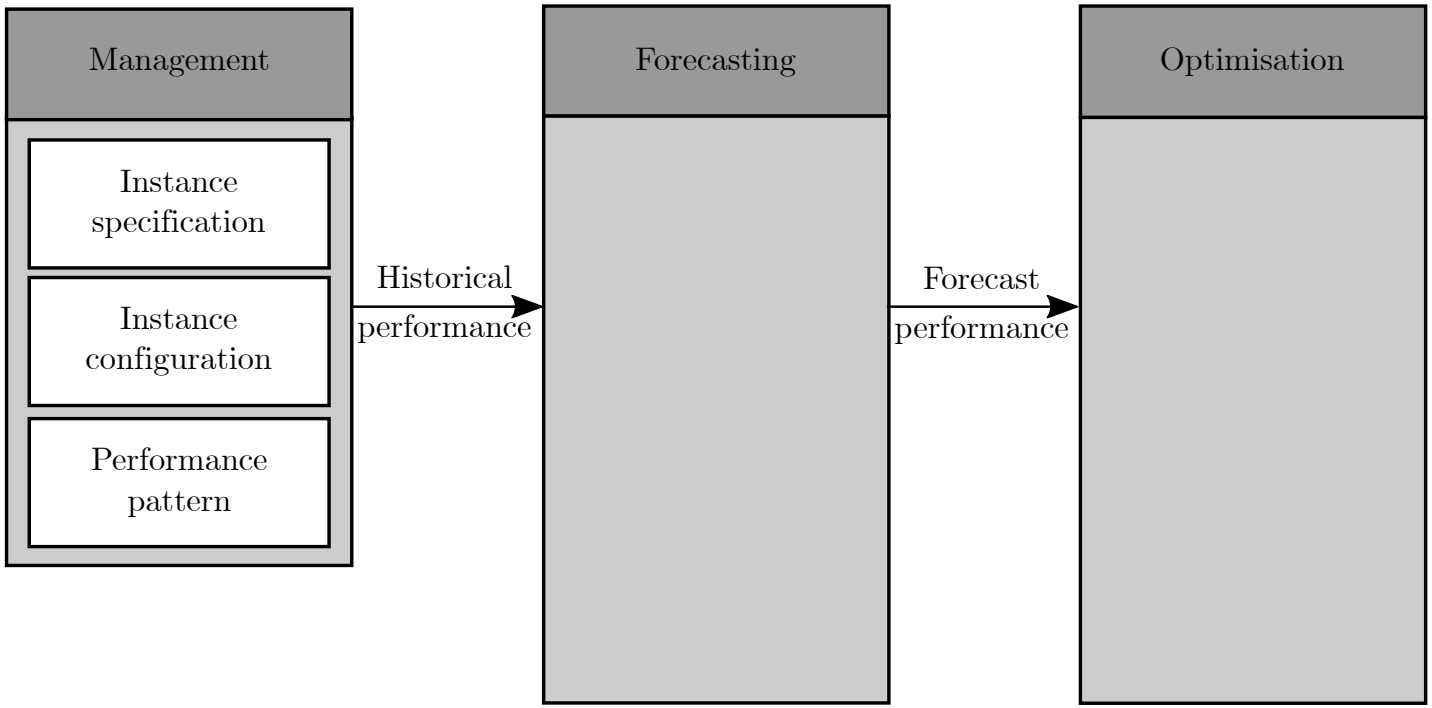

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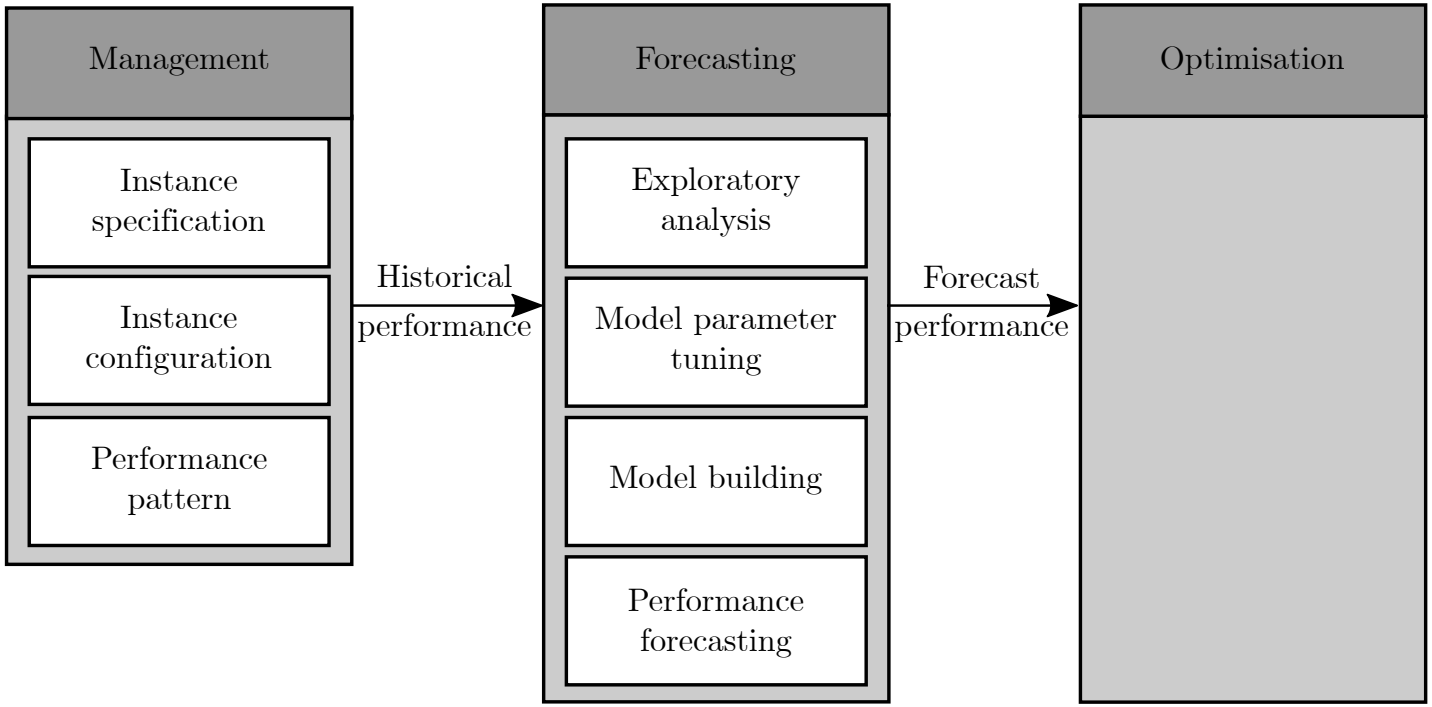
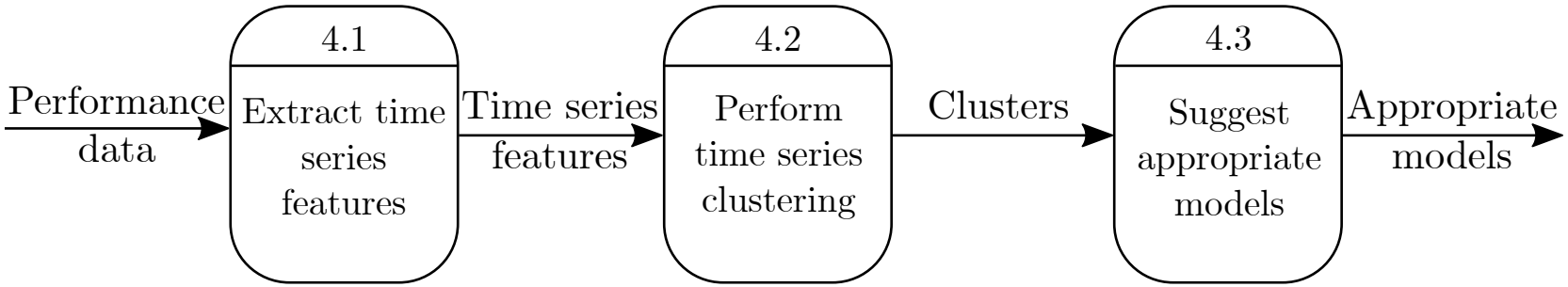


Exploratory analysis



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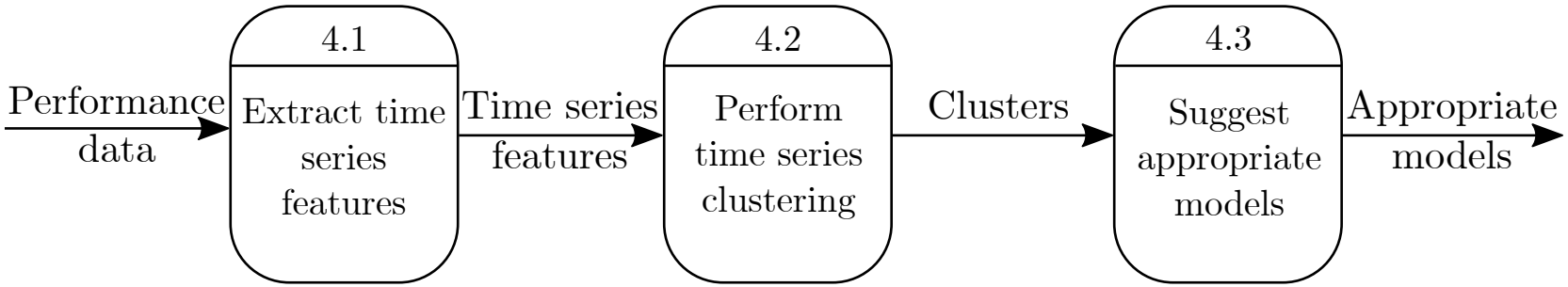

Features

- Intermittency
- Trend
- Seasonality
- Kurtosis
- Skewness
- Variation

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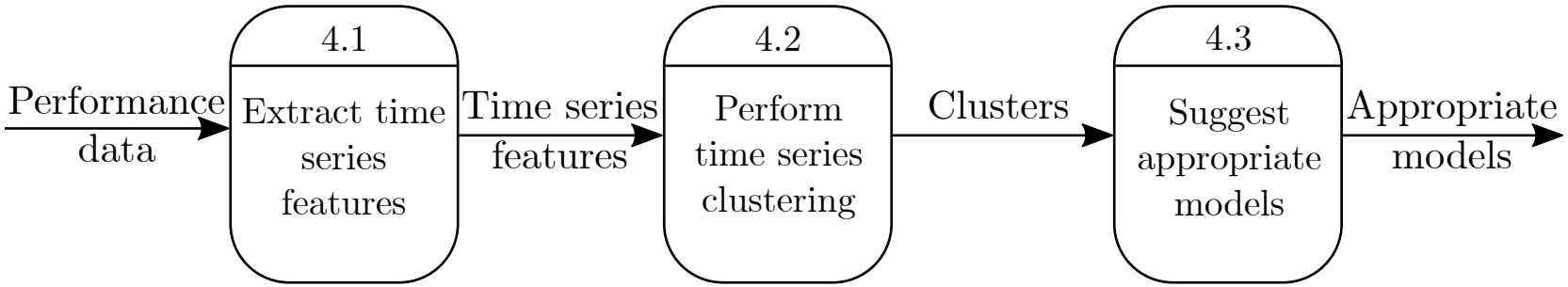

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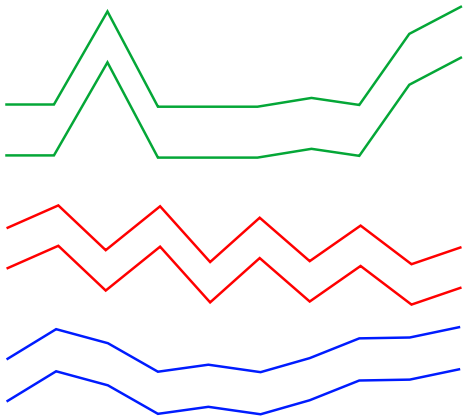

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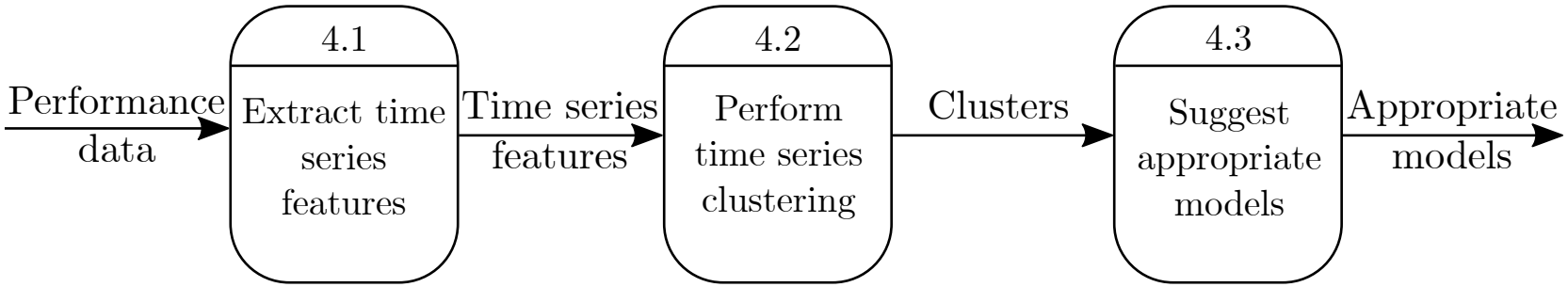

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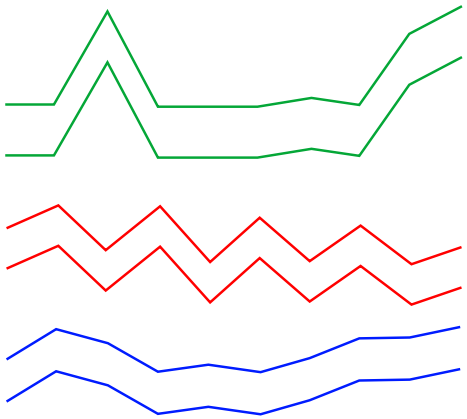


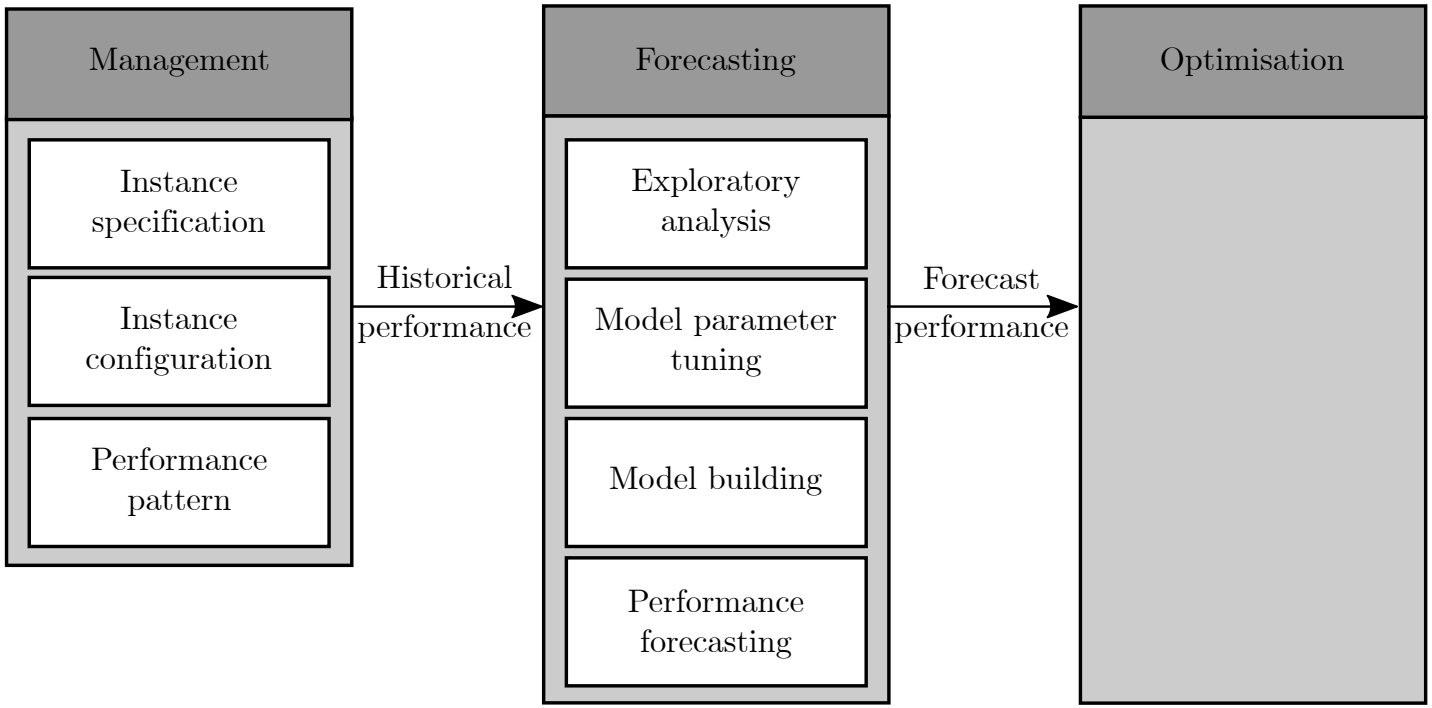
Models

- Holt Winter's
- ARIMA
- Croston
- LGBM / XGB
- Linear regression

Exploratory analysis

Cluster	kNN	ARIMA	LGBM	ETS
1	✓	–	–	–
2	✓	✓	–	✓
3	–	–	✓	✓

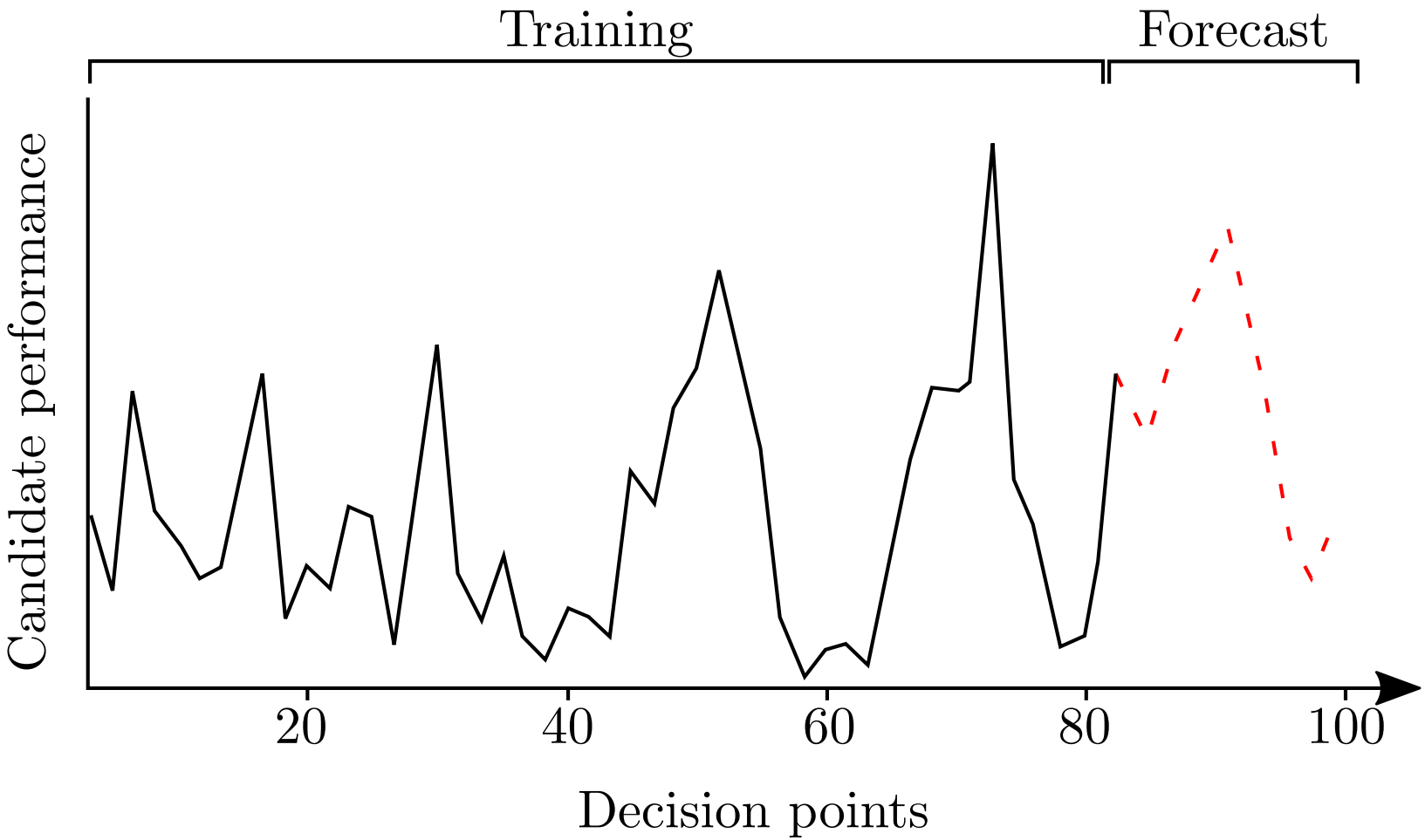
Framework design



Model building and Performance forecasting

Player	Ensemble models
37	Random Forest ARIMA XGB
55	XGB Holt Winter's Random Forest
191	kNN Linear regression LGBM

Model building and Performance forecasting



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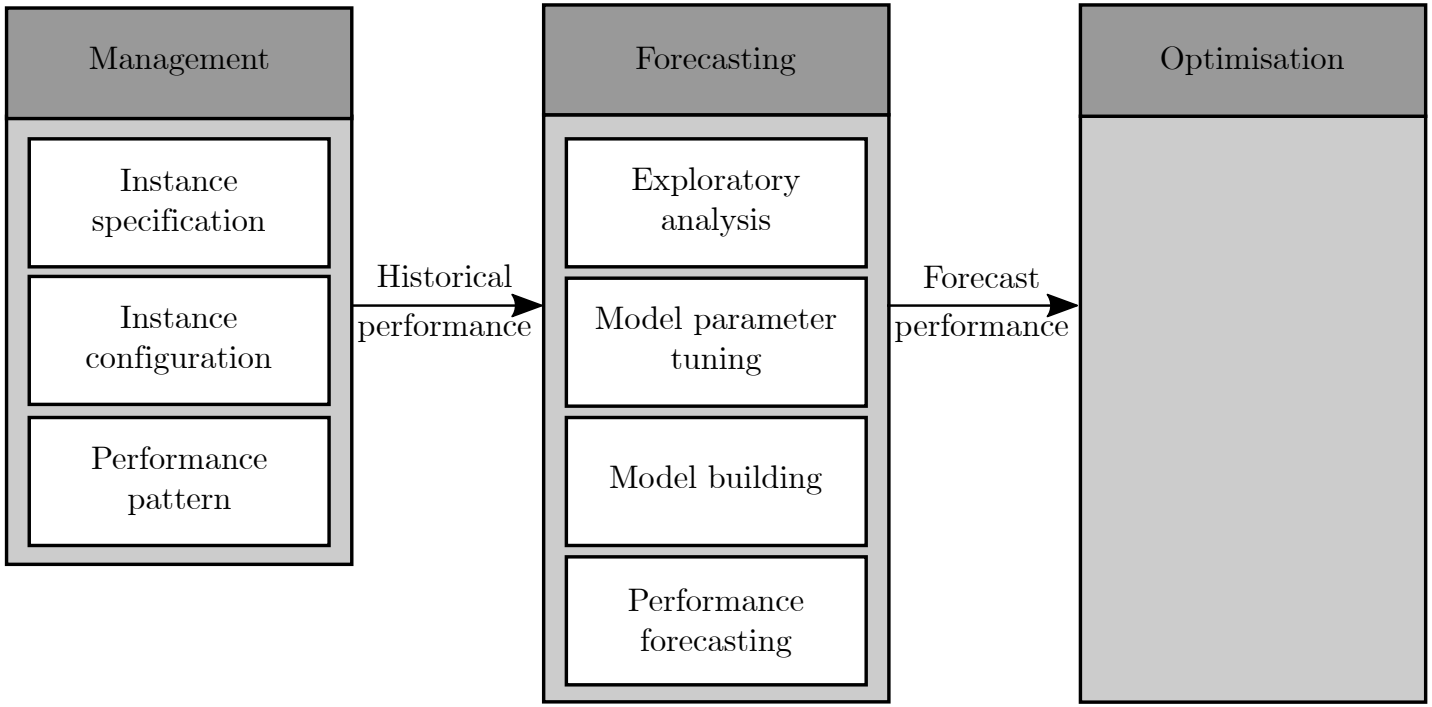

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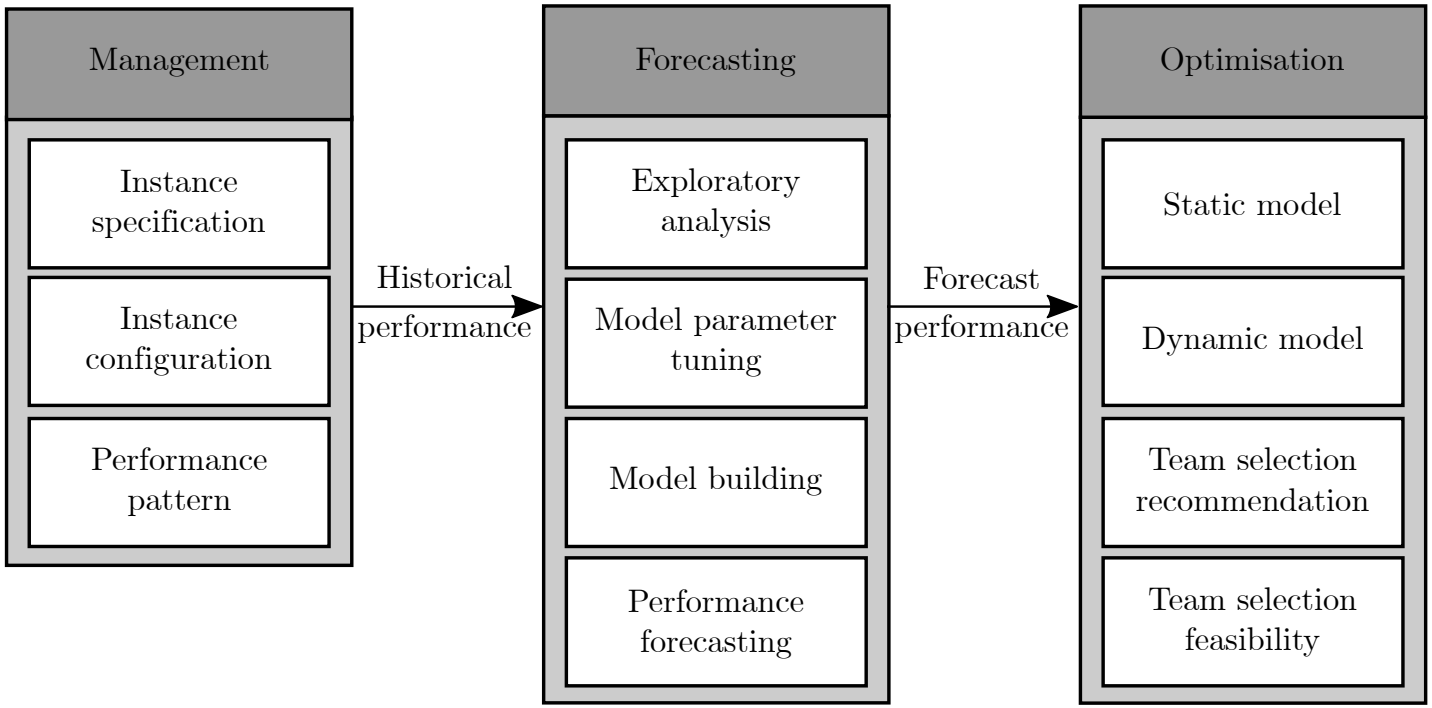
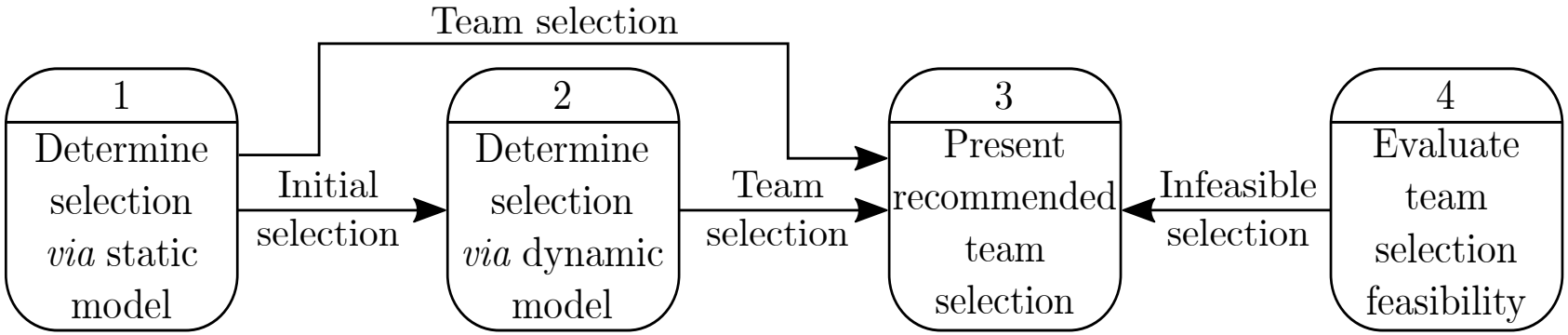


Determining CFTS



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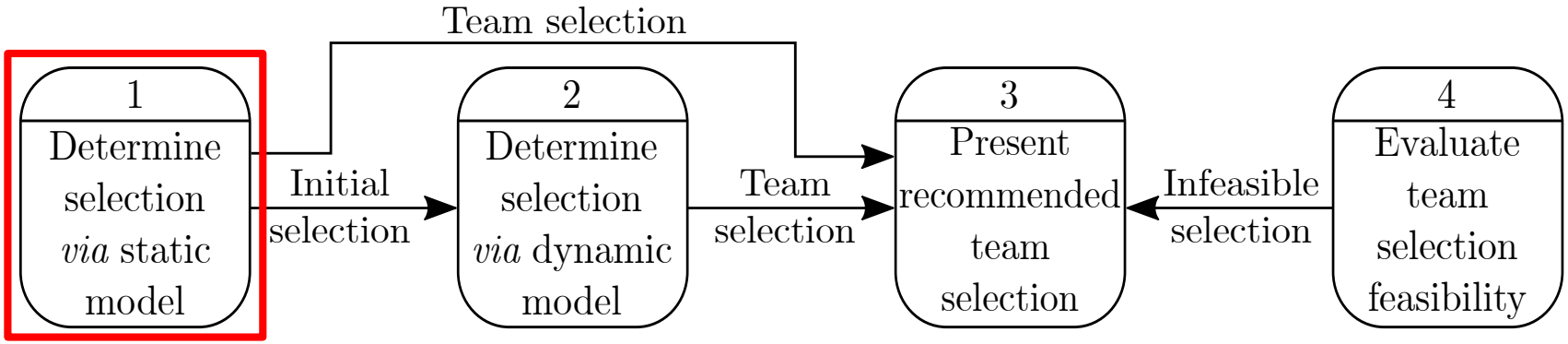

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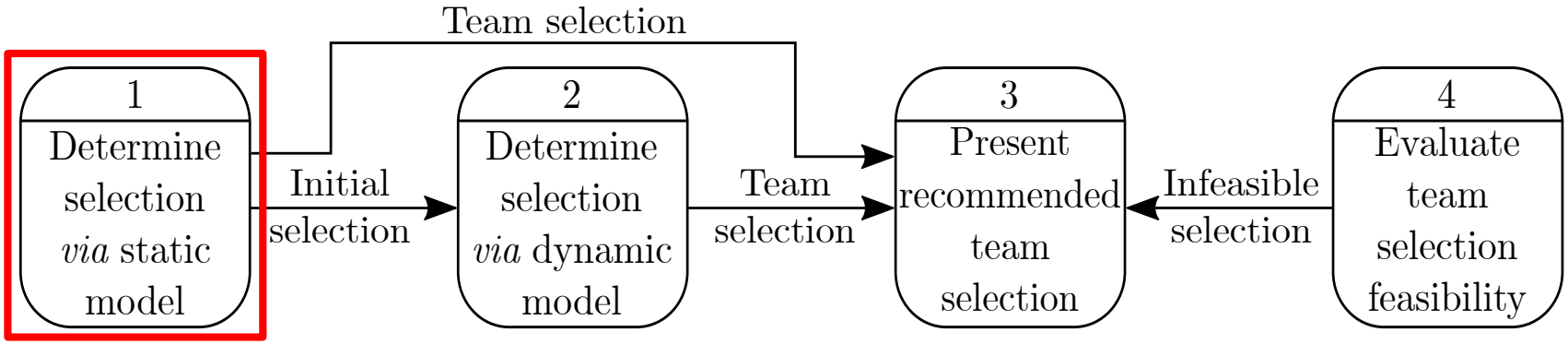
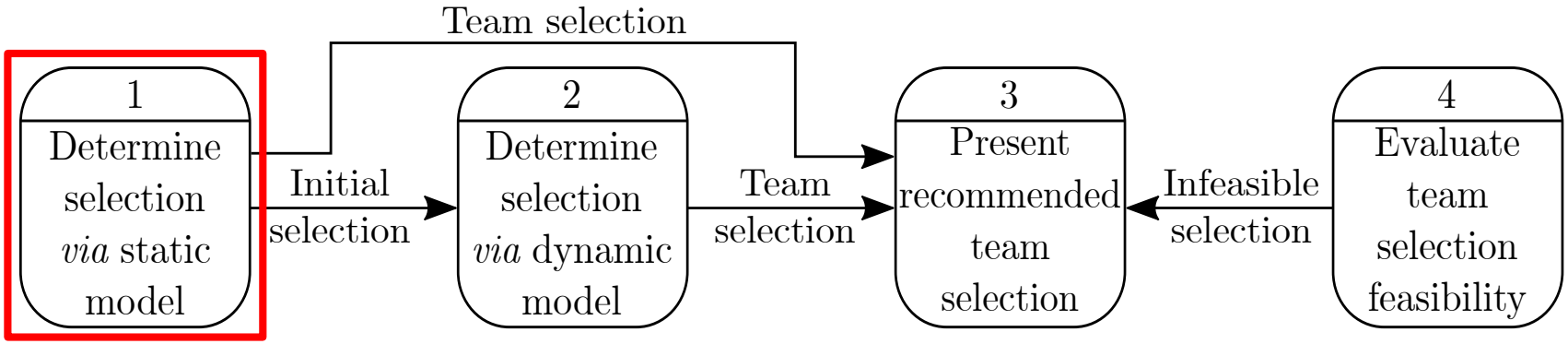


Selection *via* static model

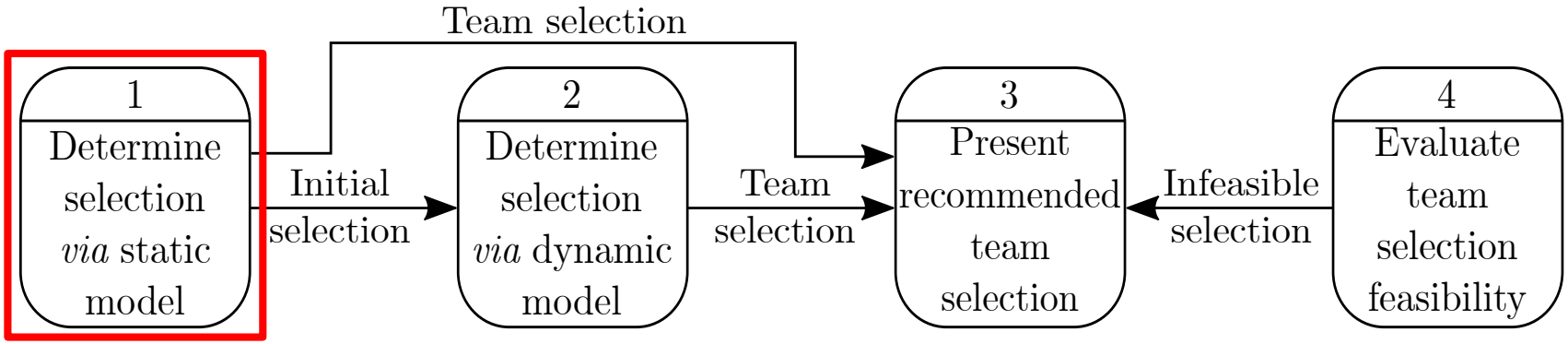
Determining CFTS



Selection *via* static model

- Team selection for first decision period (dynamic application), or entire planning horizon (static application)

Determining CFTS



Selection *via* static model

- Team selection for first decision period (dynamic application), or entire planning horizon (static application)
- Returns CFT recommendation for first decision period

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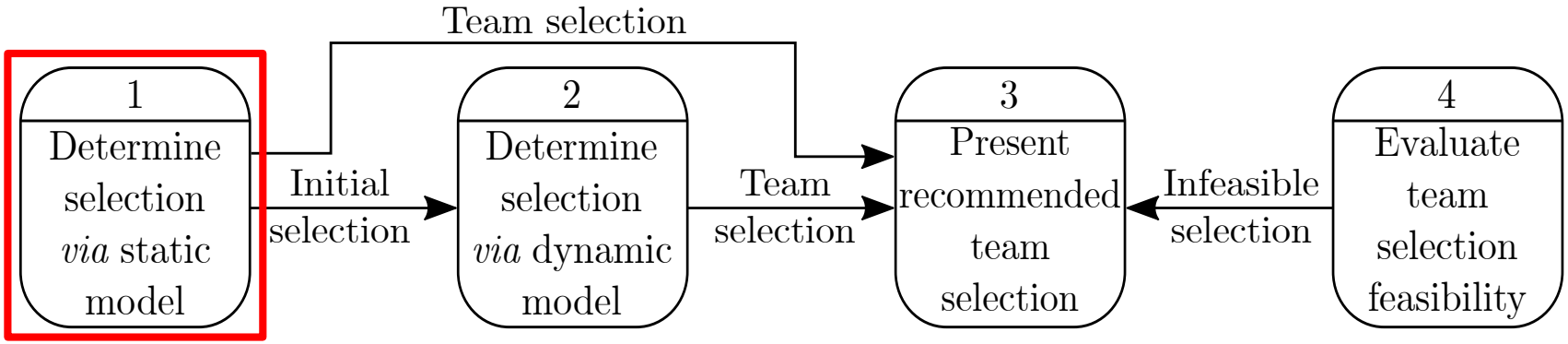

Selection *via* static model

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- Returns CFT recommendation for first decision period
- Returns temporary, advance recommendation for remaining decision periods (dynamic application)

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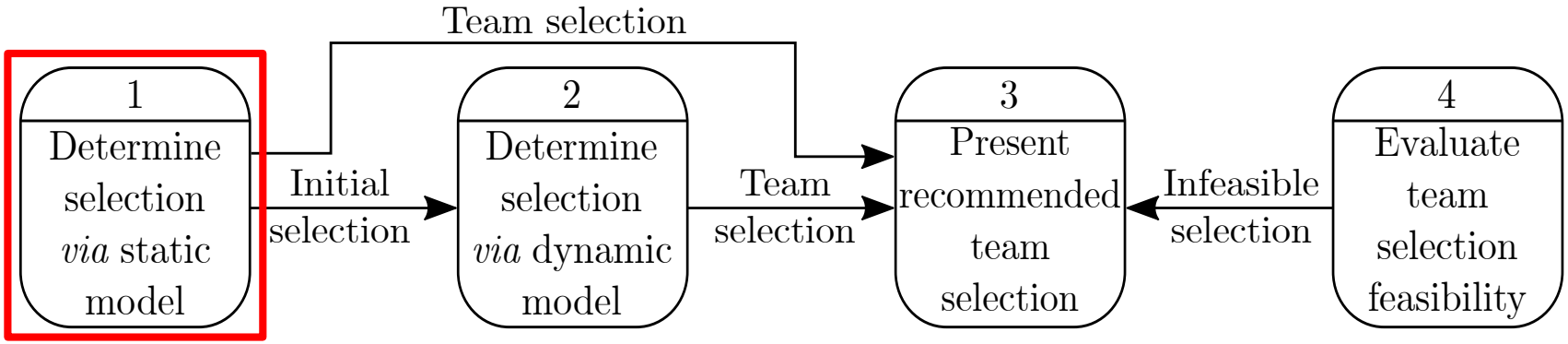

Selection *via* static model

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- Returns CFT recommendation for first decision period
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- Maximise combined expected performance score over planning horizon

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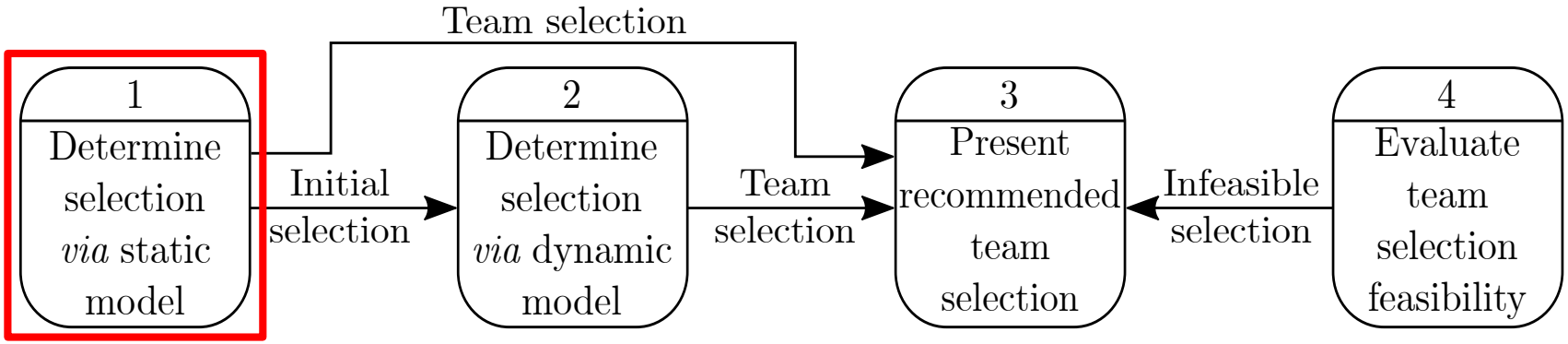

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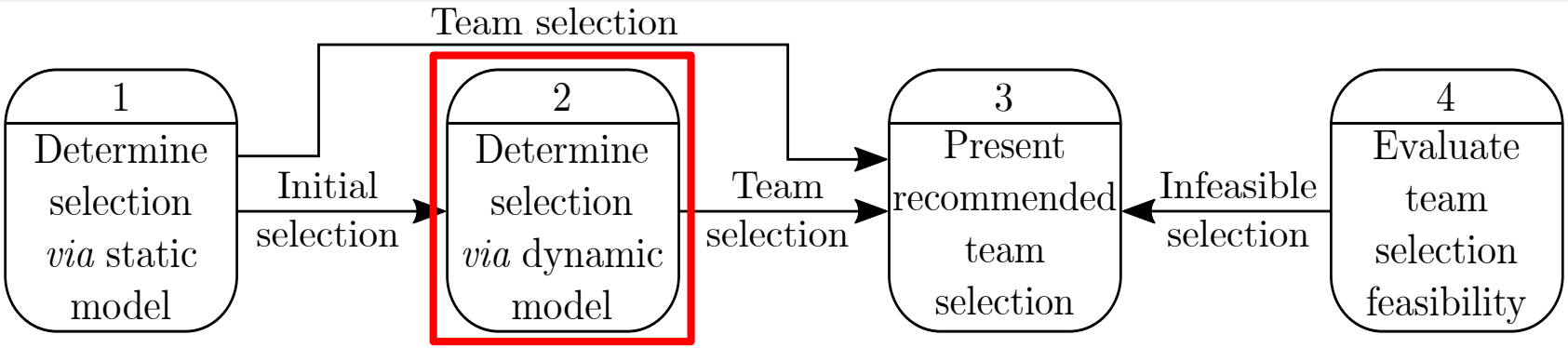
- Maximise combined expected performance score over planning horizon
- Input to dynamic model.

Determining CFTS



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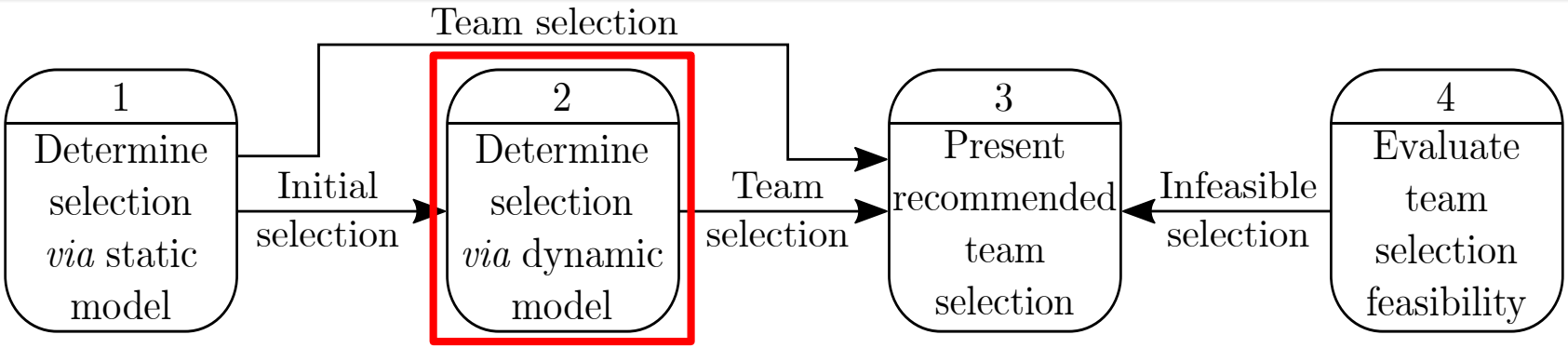

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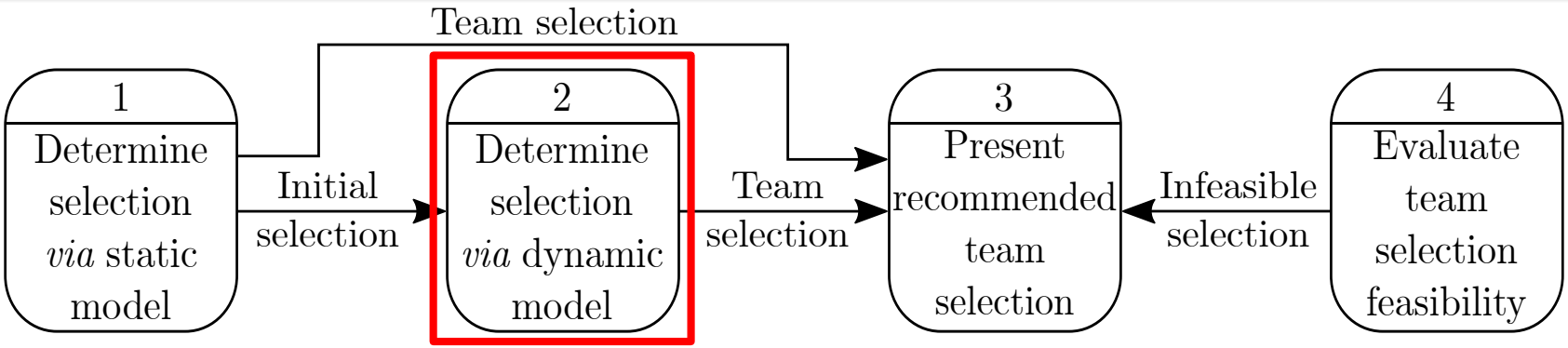

Selection *via* dynamic model

- Team selection for remainder of planning horizon

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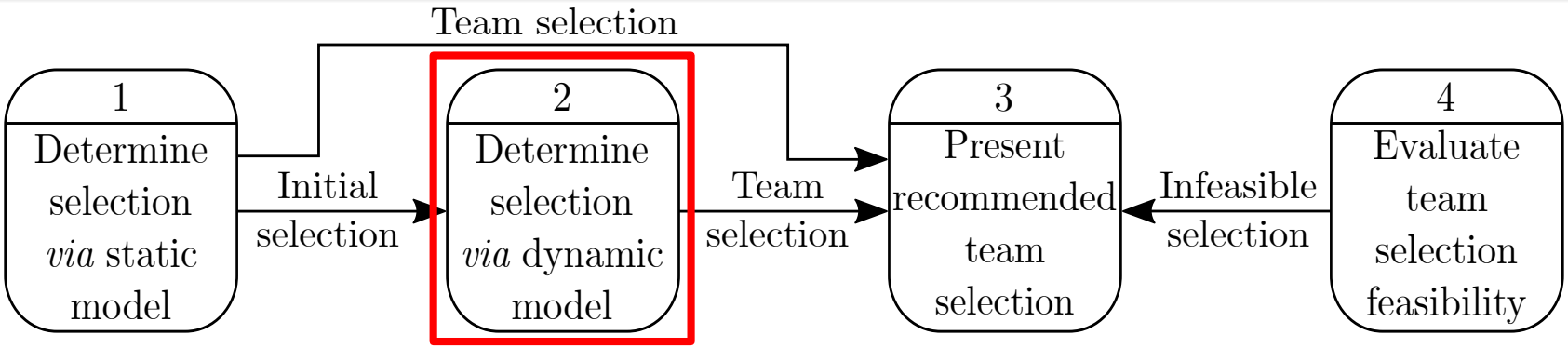
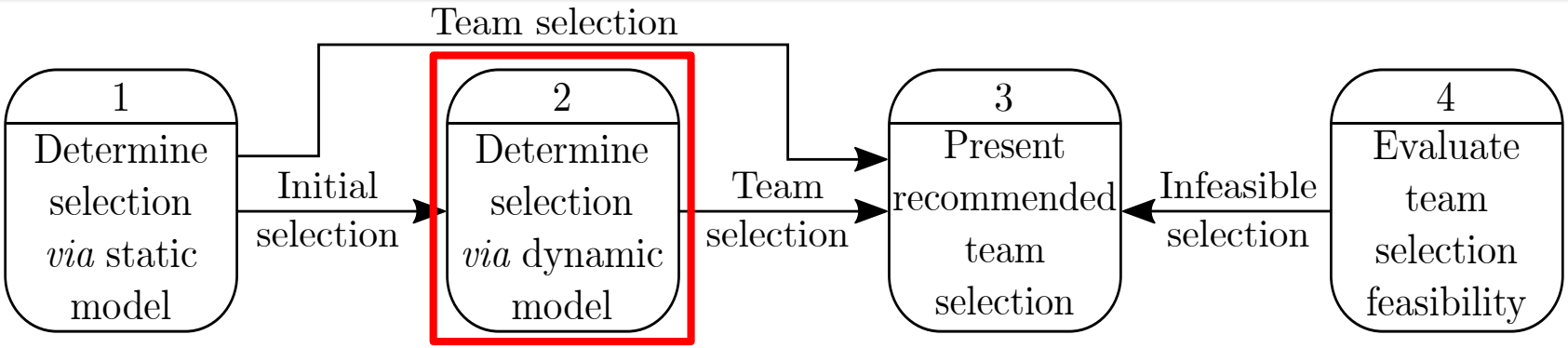


Selection *via* dynamic model

- Team selection for remainder of planning horizon
- Returns CFT substitution recommendations for each of the remaining decision periods

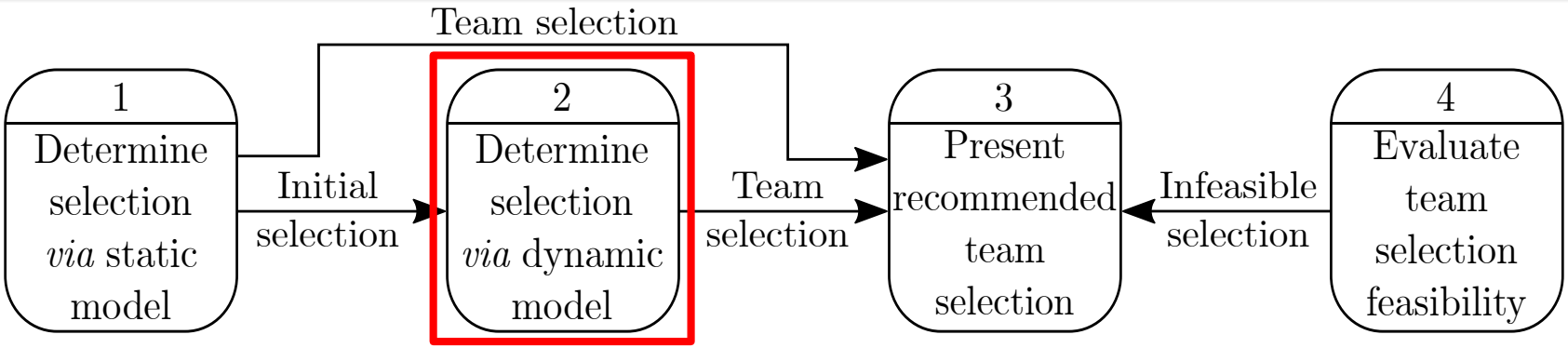
Determining CFTS



Selection *via* dynamic model

- Team selection for remainder of planning horizon
- Returns CFT substitution recommendations for each of the remaining decision periods
- CFTS recommended by static model serves as input

Determining CFTS



Selection *via* dynamic model

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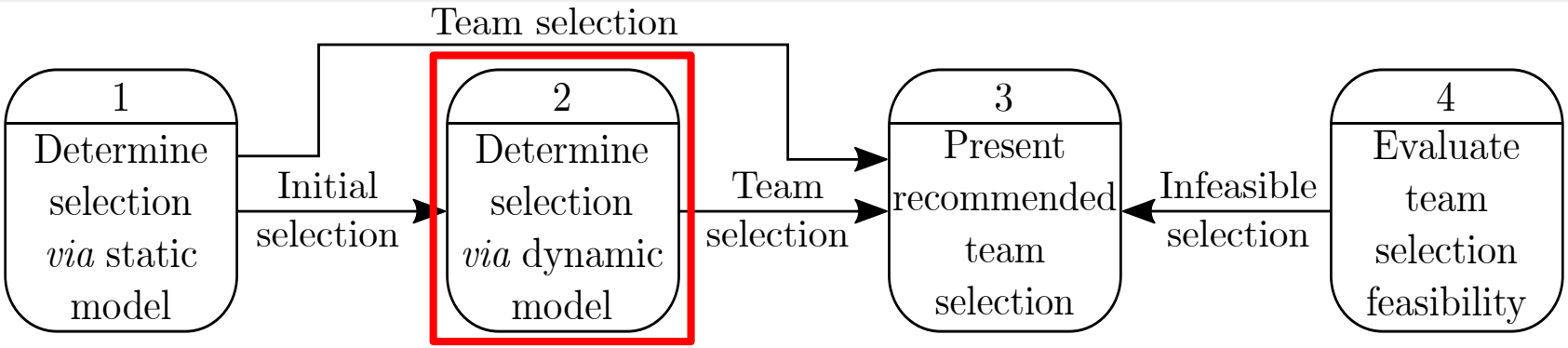

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- Maximise combined performance score over planning horizon.

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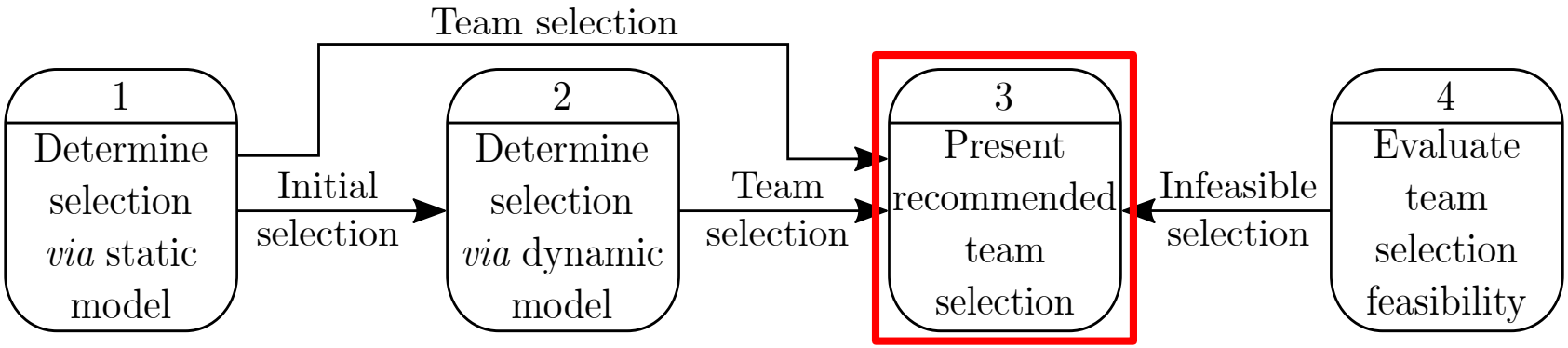

Determining CFTS

Present recommended team selection

Summary of recommended CFTSs to be considered during current decision period

Determining CFTS

Present recommended team selection

Summary of recommended CFTSs to be considered during current decision period

Candidate ID	Forecast performance score	Confirm
19	7	☐
12	6	☐
5	7	☐
10	12	☐
18	14	☐
6	14	☐

Recommended alterations

Out	In
11	19
20	10

Case study - *Fantasy Premiere League* (FPL)

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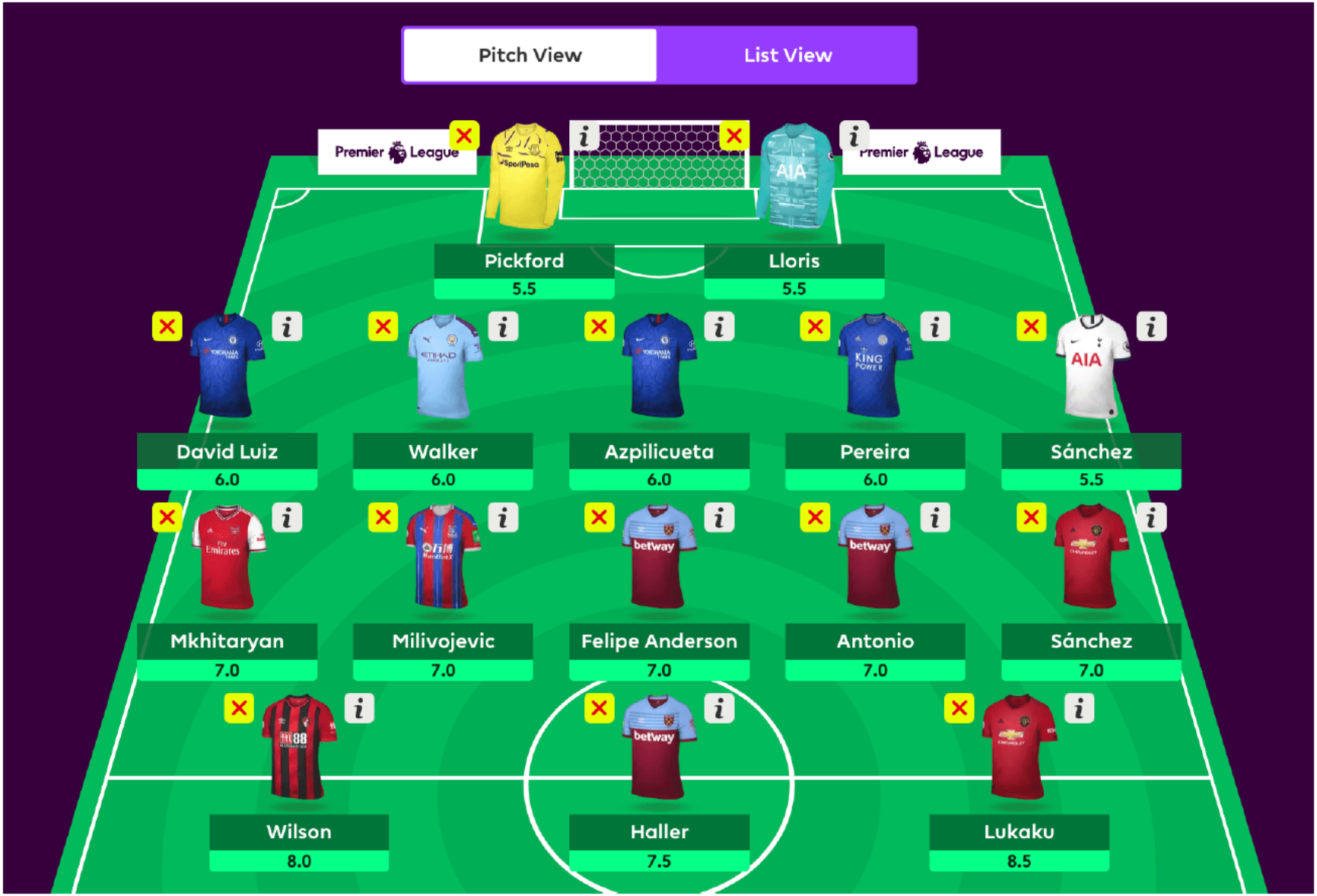

Case study: FPL

Background: 2020/2021 FPL season

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- Over 500 FPL players to select from

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- 38 Gameweeks/decision periods
- Team of 15 players/candidates needs to be selected for each decision period
- Team may be changed from one gameweek to the next

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- 38 Gameweeks/decision periods
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- 20 Teams (Chelsea, Liverpool, Manchester United, *etc.*)

Case study: FPL

Background: 2020/2021 FPL season

- Over 500 FPL players to select from
- 38 Gameweeks/decision periods
- Team of 15 players/candidates needs to be selected for each decision period
- Team may be changed from one gameweek to the next
- Budget of £100 million
- Four positions/departments (Goalkeeper, Defender, Midfielder, Forward)
- 20 Teams (Chelsea, Liverpool, Manchester United, *etc.*)
- FPL players achieve points according to how well they perform in real world *English Premiere League* (EPL) matches (*e.g.* scoring a goal = 4 points, yellow card = -1 point).

Case study: FPL

Table: Actions corresponding to points earned during EPL matches.

Points	Action
1	For playing up to 60 minutes
2	For playing 60 minutes or more
6	For each goal scored by a goalkeeper or defender
5	For each goal scored by a midfielder
4	For each goal scored by a forward
3	For each goal assist
4	For a clean sheet by a goalkeeper or defender
1	For a clean sheet by a midfielder
1	For every three shot saves by a goalkeeper
5	For each penalty save by a goalkeeper
−2	For each penalty miss by an outfield player
1–3	Bonus points for the best players in the match
−1	For every two goals conceded by a goalkeeper or defender
−1	For each yellow card
−3	For each red card
−2	For each own goal

Case study: FPL

Specifications

Case study: FPL

Specifications

- 2 Goalkeepers, 5 defenders, 5 midfielders, and 3 forwards

Case study: FPL

Specifications

- 2 Goalkeepers, 5 defenders, 5 midfielders, and 3 forwards
- At most 3 players from any one specific EPL team may be included in the squad

Case study: FPL

Specifications

- 2 Goalkeepers, 5 defenders, 5 midfielders, and 3 forwards
- At most 3 players from any one specific EPL team may be included in the squad
- One free transfer per gameweek is allowed. Penalty of four points is deducted for any additional transfers

Case study: FPL

Specifications

- 2 Goalkeepers, 5 defenders, 5 midfielders, and 3 forwards
- At most 3 players from any one specific EPL team may be included in the squad
- One free transfer per gameweek is allowed. Penalty of four points is deducted for any additional transfers
- Starting 11 team is chosen from the 15 available players in the squad. Must contain 1 goalkeeper, at least 3 defenders, and at least 1 forward. Only these 11 players' performance score contribute to the total team score

Case study: FPL

Specifications

- 2 Goalkeepers, 5 defenders, 5 midfielders, and 3 forwards
- At most 3 players from any one specific EPL team may be included in the squad
- One free transfer per gameweek is allowed. Penalty of four points is deducted for any additional transfers
- Starting 11 team is chosen from the 15 available players in the squad. Must contain 1 goalkeeper, at least 3 defenders, and at least 1 forward. Only these 11 players' performance score contribute to the total team score
- Players cost certain value.

Case study: FPL

	Team	TP	GP	Fix	Cost
Goalkeepers					
de Gea	**MUN**	26	2	EVE(H)	5.0
Sa	**WOL**	28	14	NEW(H)	5.0
Defenders					
Thisago Silva	**CHE**	24	2	SOU(H)	5.4
Rudiger	**CHE**	34	1	SOU(H)	5.6
Keane	**EVE**	27	8	MUN(A)	5.0
Cancelo	**MCI**	44	12	LIV(A)	6.1
Dias	**MCI**	39	5	LIV(A)	6.1
Midfielders					
Saka	**ARS**	26	13	BHA(A)	6..2
Gallagher	**CRY**	28	0	LEI(H)	5.7
Douccoure	**EVE**	38	11	MUN(A)	5.6
Sarr	**WAT**	39	9	LEE(A)	6.3
Townsend	**EVE**	33	10	MUN(A)	5.5
Forwards					
Vardy	**LEI**	40	11	CRY(A)	10.4
Saint-Maximin	**NEW**	35	8	WOL(A)	6.8
Ronaldo	**MUN**	21	2	EVE(H)	12.7

Case study: FPL

Objective

Maximise total FPL points for entire 2020/2021 season

Constraints

- Cost of players to include in the squad
- Only specific number of players per position
- Only certain number of player per team
- Maximum number of free tarnsfers per gameweek

Case study: Instance configuration

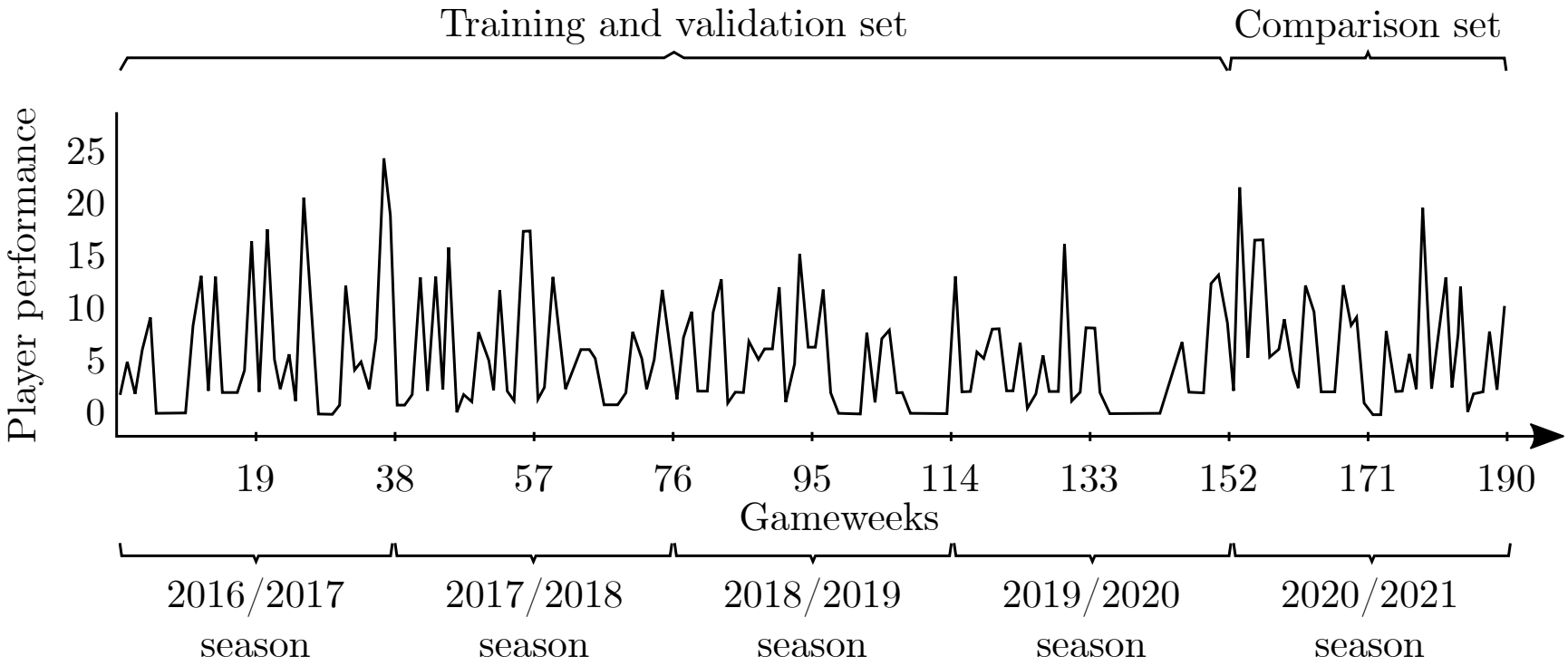
Player data for 2020/2021 FPL season

Player ID	Player name	Position
37	Jack Grealish	3
55	Dale Stephens	3
191	Zeze Steven Sessegnon	2
275	Gabriel Fernando de Jesus	4

Player data for GW 10 of the 2020/2021 FPL season

Player ID	Total points	Value	Team ID	Opposition team ID
37	10	7.6	2	19
55	0	4.3	4	12
191	7	4.5	8	8
275	21	8.2	12	4

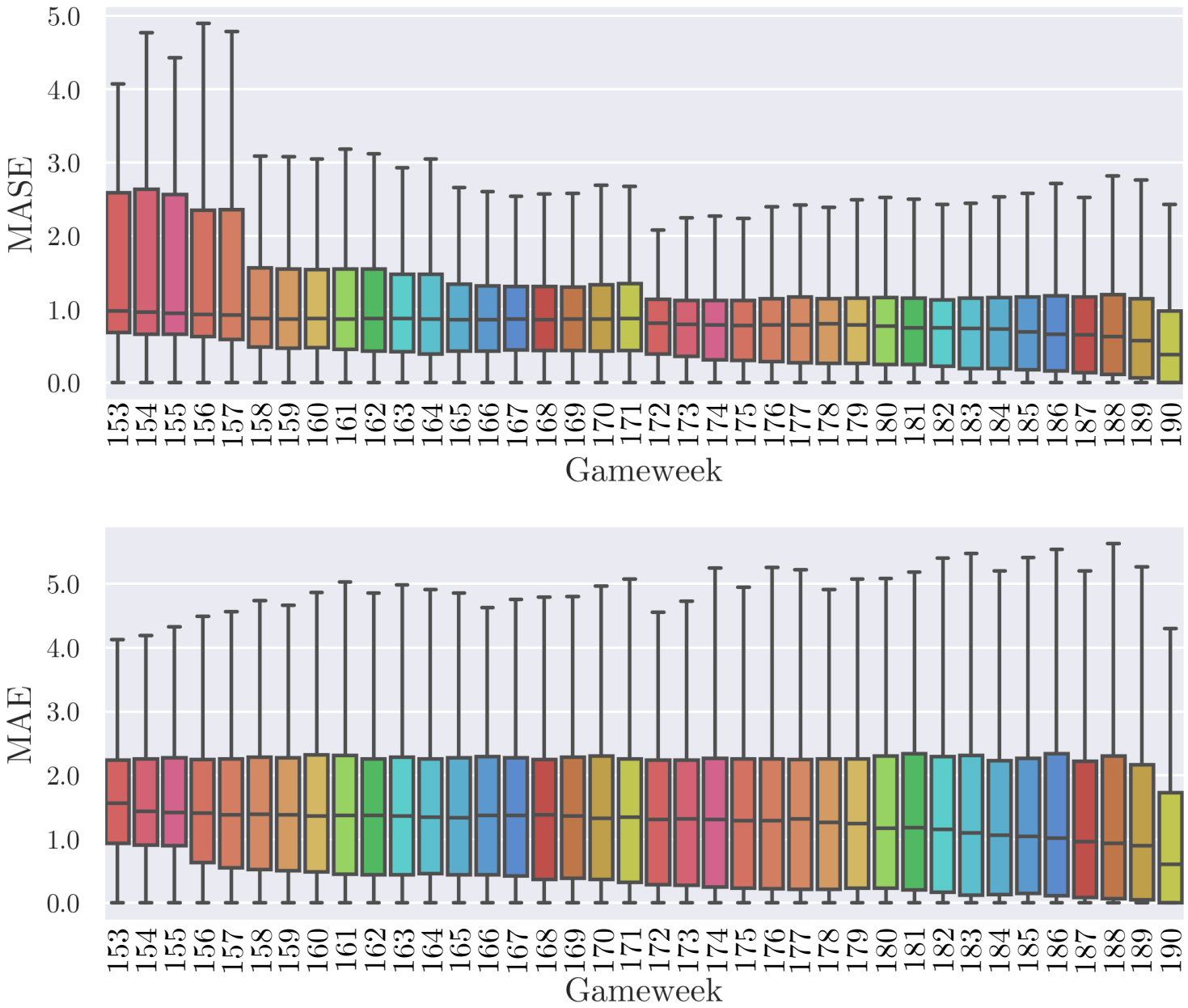
Case study - Historical performance pattern



Case study: Forecasting

Player	Ensemble models
37	Random Forest ARIMA XGB
55	XGB Holt Winter's Random Forest
191	kNN Linear regression LGBM

Case study: Forecasting



Case study: Optimisation

GW	Player	Position	Team	Cost	FPL points	Confirm	Replace by
	de Moraes	GK	Man City	60	5	—	—
	Areola	GK	Fulham	45	2	—	—
	Aina	Def	Fulham	45	0	—	—
	Adarabioya	Def	Fulham	45	1	—	—
	Dallas	Def	Leeds	45	15	—	—
	Cresswell	Def	West Ham	53	2	—	—
	Robertson	Def	Liverpool	70	2	—	—
170	Fernandes	Mid	Man Utd	105	5	—	—
	Harrison	Mid	Leeds	55	1	—	—
	Maddison	Mid	Leeds	71	8	—	—
	Foden	Mid	Man City	61	1	—	—
	Soucek	Mid	West Ham	52	2	—	—
	Kane	Fow	Spurs	110	7	—	—
	Lacazette	Fow	Arsenal	82	2	—	—
	Martial	Fow	Man Utd	87	2	—	—

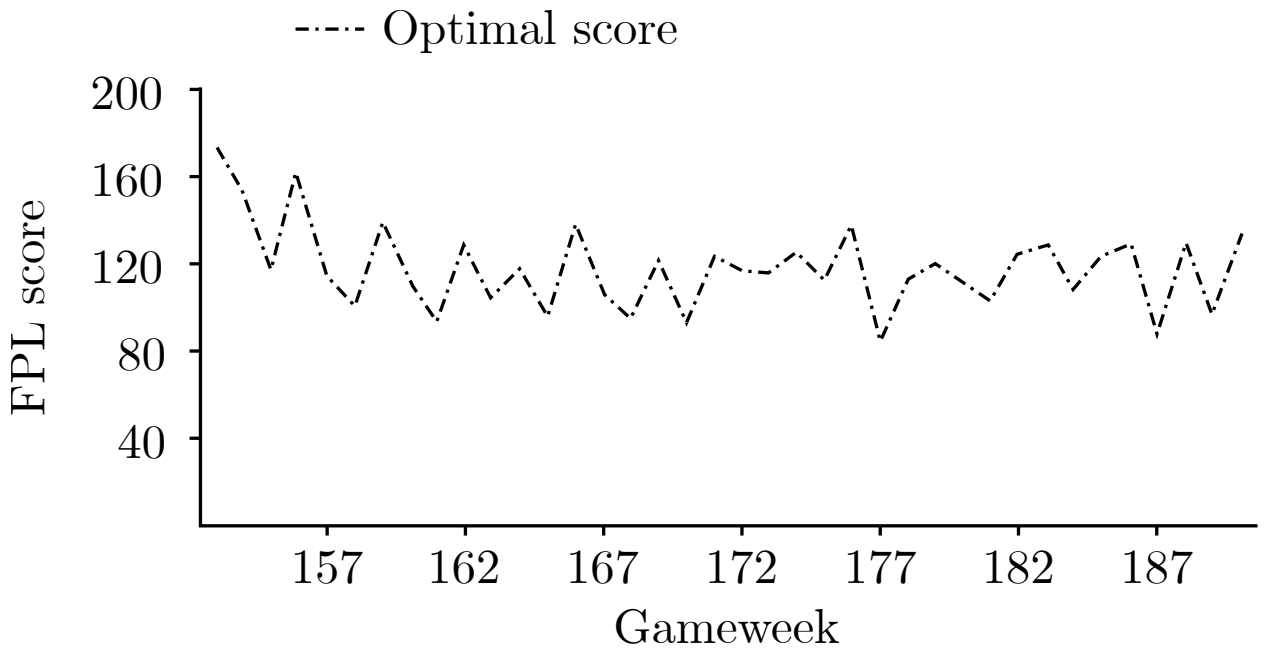
Case study: Optimisation

GW	Player	Position	Team	Cost	FPL points	Confirm	Replace by
	de Moraes	GK	Man City	60	3.70	Yes	—
	Areola	GK	Fulham	45	3.00	Yes	—
	Thiago	Def	Chelsea	56	14.00	Yes	—
	Adarabioya	Def	Fulham	45	7.00	Yes	—
	Dallas	Def	Leeds	45	5.00	Yes	—
	Cresswell	Def	West Ham	53	5.64	Yes	—
	Robertson	Def	Liverpool	70	4.32	Yes	—
171	Fernandes	Mid	Man Utd	105	7.94	Yes	—
	Traorao	Mid	Aston Villa	58	13.00	Yes	—
	Maddison	Mid	Leeds	71	5.51	Yes	—
	Foden	Mid	Man City	61	5.85	Yes	—
	Soucek	Mid	West Ham	52	4.32	Yes	—
	Kane	Fow	Spurs	110	9.85	Yes	—
	Wood	Fow	Burnley	62	6.58	Yes	—
	Martial	Fow	Man Utd	87	4.10	Yes	—

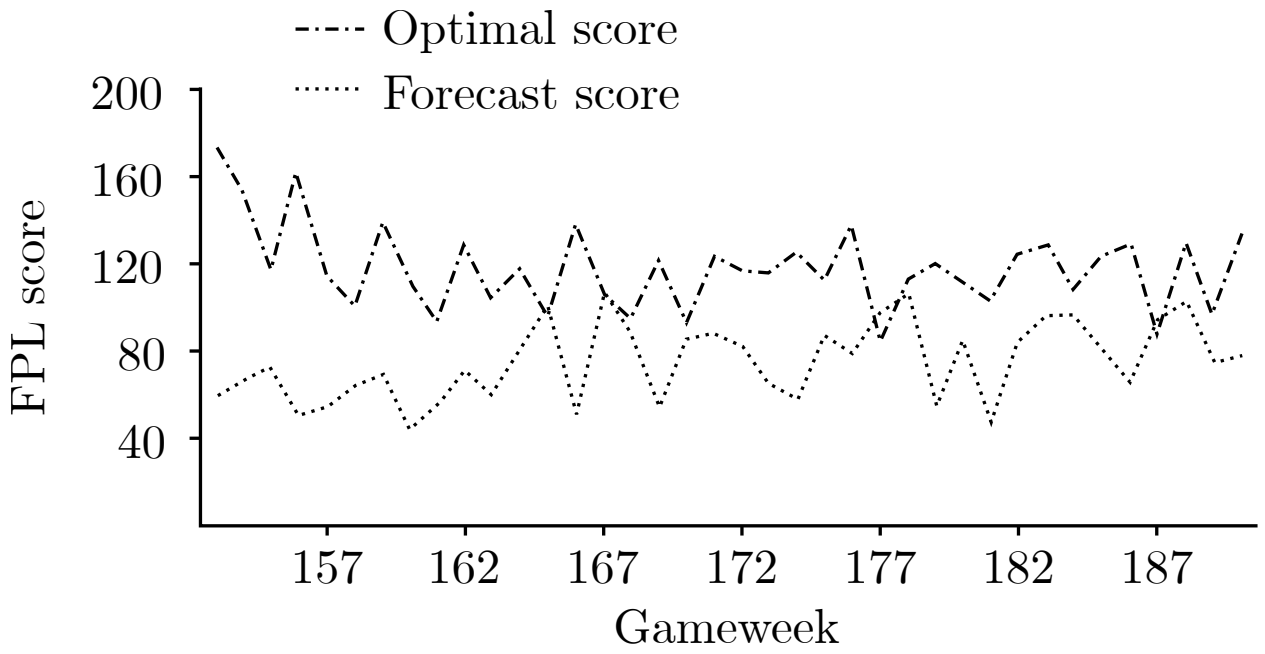
Case study: Optimisation

Player	Position	Team	FPL points
Starting eleven			
de Moraes	GK	Man City	6
Cresswell	Def	West Ham	8
Dallas	Def	Leeds	2
Thiago (c)	Def	Chelsea	12
Adarabioyo	Def	Fulham	2
Robertson	Def	Liverpool	6
Maddison	Def	Leeds	9
Foden	Mid	Man City	1
Fernandes	Mid	Man Utd	3
Wood	Mid	Burnley	2
Kane (vc)	Mid	Spurs	9
Substitutes			
Areola	Mid	Fulham	3
Martial	Fow	Man Utd	2
Traorao	Fow	Aston Villa	2
Soucek	Fow	West Ham	2
Total			60

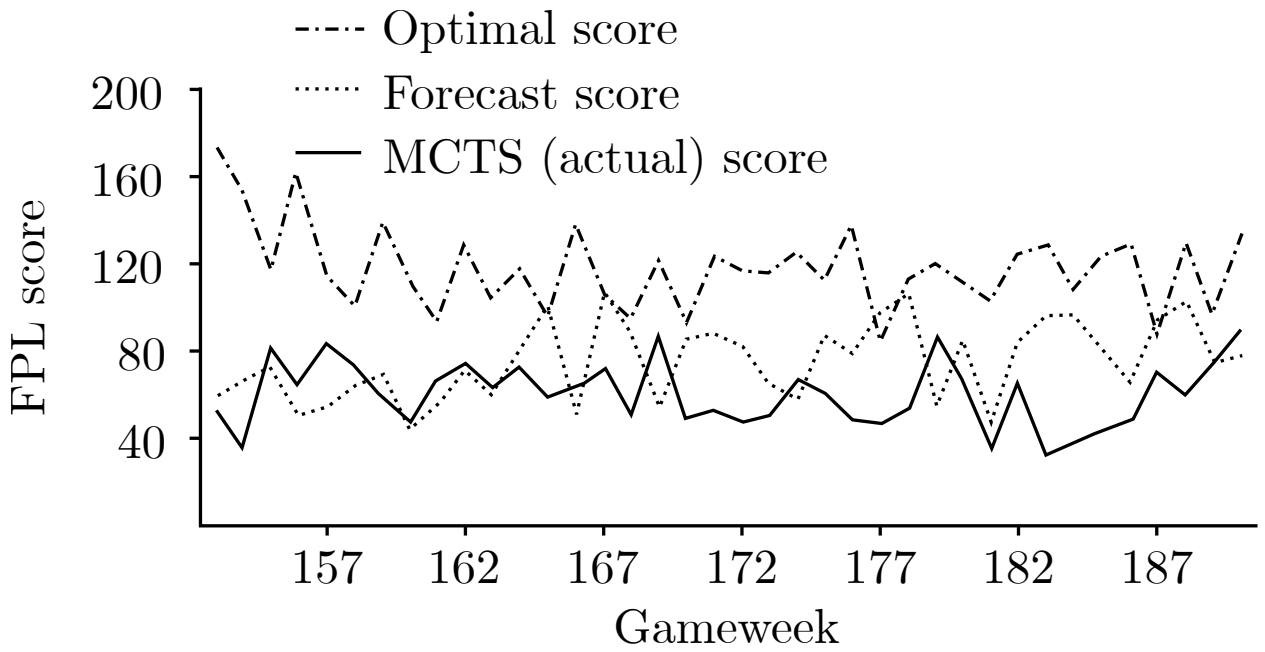
Case study: Optimisation



Case study: Optimisation



Case study: Optimisation



Performance evaluation

	Score	Rank	Percentile
Optimal score	4 501	1	$< 0.01\%$
Best FPL manager	2 680	1	$< 0.01\%$
MCTS framework	2 307	336 193	4.08%

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