

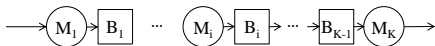


Buffer Allocation Problems for stochastic flow lines with unreliable machines

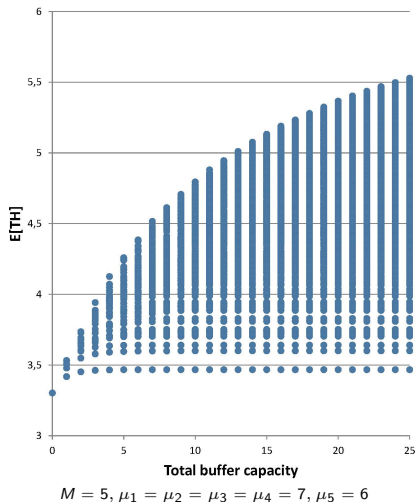
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- 1 Motivation
- 2 Classification of flow lines
- 3 Classification of Buffer Allocation Problems
- 4 Outlook: Buffer Allocation Problem Library
- 5 Conclusions and Outlook

The Buffer Allocation Problem (BAP)



- Problem is hard to solve
 - exact performance evaluation only possible for small systems under specific assumptions
 - BAP is an NP-hard problem
- No standard benchmark instances exist
- Guidelines for test case generation for performance evaluation (Gershwin, 2011)



Preliminary scope

Buffer allocation problems for serial lines with

- discrete material
- single product
- unreliable machines
- one machine per stage

published after the review of Gershwin and Schor (2000)

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Classification criteria

Line characteristics

- No. of stations
- Unbalanced (yes, no)
- Unlimited supply (yes, no)
- Infinite last buffer (yes, no)
- Scrap (yes, no)
- Transportation times (yes, no)
- Blocking type (blocking before service (BBS), blocking after service (BAS))
- Production control (flow line(F), CONWIP (C))
- Stationarity type (steady state (S), transient (T))
- Correlations (yes, no)

Classification criteria

Machine characteristics

- Processing time distribution
- Time to failure (TTF) distribution
- Time to repair (TTR) distribution
- Failure type (operating dependent (OD), time-dependent (TD))
- Conservation of work (yes, no)

Distributions

- BER Bernoulli
- ERL Erlang
- GAMMA Gamma
- LOGN Lognormal
- RA Rayleigh
- DET Deterministic
- EXP Exponential
- GEO Geometric
- NORM Normal
- U Uniform
- WEI Weibull

Classification according to the characteristics - Realistic lines

Reference	No. of stations	Unbalanced	Processing time distr.	TTF distr.	Failure type	Work-conserving	TTR distr.	Scrap	Transport. times	Blocking type	Unlimited supply	Infinite last buffer	Production control	Stationarity type	Correlations
Chiang et al. (2000)	15	x	DET	EXP	OD	*	EXP			*	x	x	F	S	
Cooke et al. (2005)	6	x	DET	EXP	OD	*	EXP			*	x	x	F	T	
Li (2013)	9,20	x	DET	EXP	*	*	EXP			*	x	x	F	S	
Liberopoulos and Tsarouhas (2005)	7	x	DET	WEI	OD,TD	*	WEI	x		*	x	x	C	S	x
Matta et al. (2005)	5	x	DET	EXP	OD	*	EXP		x	BAS	x	x	C	T	
Tempelmeier (2003)	8,19,23	x	DET	EXP	OD	*	EXP			*	x	x	F	S	
	14	x	ERL	EXP	OD	*	EXP			*	x	x	F	S	
	14	x	EXP	EXP	OD	-	EXP			*	x	x	F	S	
Tsarouhas (2014)	12	x	DET	EXP	*	*	EXP			*	x	x	C	S	
Tsarouhas and Arvanitoyannis (2010)	12	x	DET	WEI	*	*	WEI	x		*	x	x	C	S	
Tsarouhas et al. (2009)	10	x	DET	WEI	*	*	WEI	x		*	x	x	C	S	
Wang et al. (2010)	2	x	DET	BER	*	-	BER	x		*	x	x	F	T	
Xie and Li (2012)	5	x	DET	EXP	*	*	EXP			BAS	x	x	F	S	

Classification according to the characteristics - Artificial lines

Reference	No. of stations	Unbalanced	Processing time distr.	TTF distr.	Failure type	Work-conserving	TTR distr.	Scrap	Transport. times	Blocking type	Unlimited supply	Infinite last buffer	Production control	Stationarity type	Correlations
Alon et al. (2005)	3,5,6,10	x	EXP	EXP	TD	-	EXP			*	x	x	F	S	
	5	x	ERL	EXP	TD	*	EXP			*	x	x	F	S	
Bekker (2013)	5	x	EXP	EXP	OD	x	EXP			*	x	x	F	S	
Demir et al. (2011)	5,9,10		DET	GEO	*	-	GEO			*	x	x	F	S	
	12,20,40		DET	GEO	*	-	GEO			*	x	x	F	S	
Demir et al. (2013)	5,10,20	x	DET	GEO	*	-	GEO			*	x	x	F	S	
Diamantidis and Papadopoulos (2004)	4-6,10	x	DET	BER	OD	-	BER			*	x	x	F	S	
Dolgui et al. (2002)	5	x	DET	EXP	OD	*	EXP			*	x	x	F	S	
Dolgui et al. (2007)	5-8		DET	EXP	OD	*	EXP			*	x	x	F	S	
Enginarlar et al. (2002)	2-20		DET	EXP	*	*	EXP			BBS	x	x	F	S	
	2-20		DET	ERL	*	*	ERL			BBS	x	x	F	S	
	2-20		DET	RA	*	*	RA			BBS	x	x	F	S	
Enginarlar et al. (2005)	3-30		DET	EXP	TD	*	EXP			BBS	x	x	F	S	
Gershwin and Schor (2000)	5,12		DET	GEO	*	-	GEO			*	x	x	F	S	
	7		DET	EXP	*	*	EXP			*	x	x	F	S	
Han and Park (2002)	5,10		DET	GEO	*	-	GEO	x		*	x	x	F	S	
Helber (2001)	6		DET	GEO	OD	-	GEO			*	x	x	F	S	
Kim and Lee (2001)	3,8,10		EXP	EXP	OD	x	EXP			BAS	x	x	F	S	

Classification according to the characteristics - Artificial lines

Reference	No. of stations	Unbalanced	Processing time distr.	TTF distr.	Failure type	Work-conserving	TTR distr.	Scrap	Transport. times	Blocking type	Unlimited supply	Infinite last buffer	Production control	Stationarity type	Correlations
Kose and Kilincci (2015)	5,10,20		DET	GEO	*	-	GEO			*	x	x	F	S	
	9,20,40		DET	GEO	*	-	GEO			*	x	x	F	S	
Lee et al. (2009)	5		DET	GEO	OD	-	GEO			BBS	x	x	F	S	
Lee and Ho (2002)	5,6	x	EXP	EXP	*	-	EXP			*		x	F	S	
	5,6		EXP	EXP	*	-	EXP			*		x	F	S	
Massim et al. (2010)	3,5,10		DET	EXP	OD	*	EXP			*	x	x	F	S	
Matta et al. (2012)	5	x	DET	EXP	OD	*	EXP			*	x	x	F	S	
	12		DET	GEO	OD	-	GEO			*	x	x	F	S	
Nahas et al. (2006)	7,10	x	DET	EXP	OD	x	EXP			BAS	x	x	F	S	
Papadopoulos and Vidalis (2001)	3-6	x	EXP	EXP	OD	x	EXP			BAS	x	x	F	S	
Sabuncuoglu et al. (2006)	3,5,10		DET	EXP	OD	x	EXP			*	x	x	F	S	
	4-6,8-10	x	EXP	EXP	OD	x	EXP			*	x	x	F	S	
	4,5	x	DET	EXP	OD	x	EXP			*	x	x	F	S	
	7-10,12	x	DET	EXP	OD	x	EXP			*	x	x	F	S	
Savsar (2006)	5	x	EXP	EXP	OD,TD	*	U			*	x	x	F	S	
	5	x	DET	U/EXP/ NORM/ ERL/ GAMMA	OD,TD	*	U/ NORM/ LOGN/ DET			*	x	x	F	S	

Classification according to the characteristics - Artificial lines

Reference	No. of stations	Unbalanced	Processing time distr.	TTF distr.	Failure type	Work-conserving	TTR distr.	Scrap	Transport. times	Blocking type	Unlimited supply	Infinite last buffer	Production control	Stationarity type	Correlations
Shi and Gershwin (2009)	3-6,12	x	DET	GEO	*	-	GEO			*	x	x	F	S	
Shi and Gershwin (2014)	20,30,70		DET	GEO	*	-	GEO			*	x	x	F	S	
	20		DET	GEO	*	-	GEO			*	x	x	F	S	
Shi and Men (2003)	9		DET	GEO	*	-	GEO			*	x	x	F	S	
Weiss and Stolletz (2015)	14,24	x	DET/ ERL	EXP	OD	x	EXP			BAS	x	x	F	S	x

- References that consider balanced flow lines prevail
- Processing times mostly DET with EXP or GEO distributed TTF and TTR
- OD-failures dominate TD-failures
- Some instance are based on existing instances:
 - Gershwin and Schor (2000): Kose and Kilincci (2015), Demir et al. (2011), and Lee et al. (2009)
 - Papadopoulos and Vidalis (2001): Sabuncuoglu et al. (2006)
 - Vouros and Papadopoulos (1998): Bekker (2013), Dolgui et al. (2007), Alon et al. (2005), and Dolgui et al. (2002)

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Classification criteria

Primal Problem:

$$\min \sum_{i=1}^{K-1} B_i$$

s.t.

$$Th(\mathbf{B}) \geq Th^*$$

$$B_i \in \mathbb{N}_0, \quad 1 \leq i \leq K-1$$

Dual Problem:

$$\max Th(\mathbf{B})$$

s.t.

$$\sum_{i=1}^{K-1} B_i = B_{tot}$$

$$B_i \in \mathbb{N}_0, \quad 1 \leq i \leq K-1$$

Classification criteria

Profit Problem:

$$\max \text{Profit} = \alpha Th(\mathbf{B}) - \beta WIP(\mathbf{B}) - \gamma \mathbf{B}$$

s.t.

$$\sum_{i=1}^{K-1} B_i \leq B_{tot}$$

$$Th(\mathbf{B}) \geq Th^*$$

$$B_i \in \mathbb{N}_0, \quad 1 \leq i \leq K - 1$$

Other Problems:

- Net present value
- Multi-objective functions
- ...

Classification according to the decision problem

Reference	Primal	Dual	Profit	Others	Reference	Primal	Dual	Profit	Others
Alon et al. (2005)		x			Lee et al. (2009)		x		
Bekker (2013)				x	Lee and Ho (2002)				x
Chiang et al. (2000)	x				Li (2013)	x			
Demir et al. (2011)	x	x			Massim et al. (2010)			x	
Demir et al. (2013)	x				Matta et al. (2012)	x			
Diamantidis and Papadopoulos (2004)		x			Nahas et al. (2006)		x		
Dolgui et al. (2002)			x		Papadopoulos and Vidalis (2001)		x		
Dolgui et al. (2007)			x		Sabuncuoglu et al. (2006)		x		
Enginarlar et al. (2002)	x				Savsar (2006)		x		
Enginarlar et al. (2005)	x				Shi and Gershwin (2009)			x	
Gershwin and Schor (2000)	x	x	x		Shi and Gershwin (2014)			x	
Han and Park (2002)	x				Shi and Men (2003)		x		
Helber (2001)				x	Tempelmeier (2003)	x	x		
Kim and Lee (2001)				x	Weiss and Stolletz (2015)	x			
Kose and Kilincci (2015)		x							

- Primal and dual BAPs are most common

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Conclusions and Outlook

Conclusion

- Classification scheme for serial flow lines
- Basis for the development of an online library of test instances
- Insufficiently addressed features of realistic lines: Correlations and transient effects

Outlook

- Online library of test instances
- Other realistic lines in literature
- Networks

Appendix: Literature I

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Appendix: Literature II

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Appendix: Literature III

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Appendix: Literature IV

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