Who Should Own Float? Mitigating Delays by Float Pre-Allocation

by

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Overview

- Introduction
- Political Apportionment Methods
  - Largest remainder method
  - Divisor methods
- Methodology
  - Float pre-allocation model
  - Simulation process
- Case Study
- Conclusions

Introduction

- Construction projects often incur delays
  - Delays: “an act or event that extends the time required to perform tasks under a contract” (Stumpf 2000, p. 32)
  - Most crucial: critical path activities delay

- General approach: project buffer on critical chain
  - Single large end buffer, without tracking by whom
  - Not properly protect project (Herrorlen and Leus 2001)

- Classical research question: who owns float?
- How can available project float be used most beneficially by allocating it to activities who by definition have none and determining how much each receives?

Introduction

- Similarities
  - Political apportionment :
  how to divide integer number representatives according to respective sizes (Verba 2003)

  - Float pre-allocation

Table 1: Analogies between Political Apportionment and Float Preallocation

Similarities	Float Preallocation	Political Apportionment
Why apportionment (Goal/motivation)	Fairness for distributing float	"[E]qual influence over government policy across citizens" (Verba 2003, p. 663)
What is equalizing (subject)	Float/time/ability of excusable delay when making schedule	Seats/power of voting when making policy
How to apportion	Rounding, because schedule is in integer days	Rounding, because no fractional seats are allowed

Need for Research

- Inspired by political apportionment approaches, this paper will develop analogous approach to distribute project float to every critical activity. three **Research Objectives** are set:
  - Reviewing different rounding methods that are used in political voting and extracting their pertinent features
  - Creating a methodology to integrate apportionment methods and their rounding into pre-allocating project float
  - Conducting a simulation of a sufficiently complex schedule to validate these methods and compare their results

Political Apportionment Methods

- Largest remainder method

- Divisor methods:

require select divisor based on generalized power mean for specific parameter values (Jones and Wilson 2010)

- Greatest divisor
- Smallest divisor
- Geometric mean
- Harmonic mean
- Arithmetic mean

Political Apportionment Methods

- Example: 45 seats, four parties

votes: A (61), B (48), C(20), D (7)

- Largest remainder method
  - Calculate proportion of each party, e.g. A: 61/(61+48+20+7)=44.85%
  - Get unrounded seat (quota), A: 44.85% × 45 = 20.18
  - Round down to integer, A(20), B(15), C(6), D(2), total 43
  - Leftover 2 seats are given to the parties with largest remainders, B and C
  - Final apportionment: A(20), B(16), C(7), D(2)
  - '*Alabama Paradox*': increasing seats in the house "has caused the smallest party to lose a seat" (Wiseman 2015)

Political Apportionment Methods

- Divisor methods
  - Greatest divisor: quota / divisor, round down
  - Smallest divisor: quota / divisor, round up
  - Geometric mean: round down quota (q), geometric mean $(q \times (q+1))^{1/2}$, judge: if $q < GM$, round up GM; if $q > GM$, round down GM
  - Harmonic mean: employs harmonic mean
  - Arithmetic mean: employs arithmetic mean
  - Divisor must be iteratively adjusted until total seat reached

Table 2: Results of Distributing Seats for Four Parties with Different Apportionment Methods

	Target Proportion						Quota Unrounded				Seats			
Method Name	A	B	C	D	**Total Seats**	**Divisor**	A	B	C	D	A	B	C	D
Largest Remainder	61	48	20	7	45	N/A	20.18	15.88	6.62	2.32	20	16	7	2
Greatest Divisor						2.90	21.03	16.55	6.90	2.41	21	16	6	2
Smallest Divisor						3.20	19.06	15.00	6.25	2.19	20	15	7	3
Geometric Mean						3.02	20.49	15.49	6.48	2.45	20	16	7	2
Harmonic Mean						3.02	20.49	15.48	6.46	2.40	20	16	7	2
Arithmetic Mean						3.07	19.87	15.64	6.51	2.28	20	16	7	2

Methodology

- Float Pre-allocation Model
- *n* critical activities with fixed duration *Di* ,use it as base
- Exponents, 0, 0.5, 1 cases to get quotas accordingly
- Apply different apportionment method returns pre-allocation

(a_1, …, a_n), where $\sum_i a_i = FLOAT$

Table 3: Structure of Float Arrangement Model based on Apportionment Methods

Exponent of Duration	Target Proportions (Quotas)					Float to Apportion	Apportionment Method	Float Apportionment
	Act 1	Act 2	Act 3	…	Act n			
0.0	1	1	1	…	1			
0.5	$D_1^{0.5}$	$D_2^{0.5}$	$D_2^{0.5}$	…	$D_n^{0.5}$	FLOAT	LR, GD, SD, GM, HM, AM	$(a_1, \ldots, a_n)$
1.0	D_1	D_2	D_2	…	D_n			

Note: Different rounding approaches are already included in the apportionment methods.

Methodology

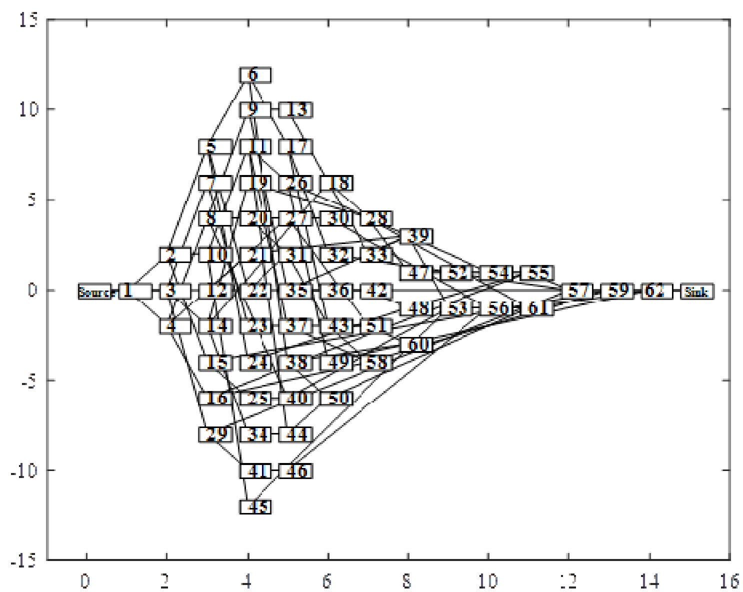
- Simulation Process
  - *n* critical activities with random duration *di*
  - Compare: rounded-up integer delay $\lceil d_i - D_i \rceil$ and arranged float a_i
  - Overruns: discrete count and continuous measurement of delay
  - Goal: best exponent case and apportionment method to stop overrunning ***the fastest***

Table 4: Structure of Simulation Process

Run	Simulation					Float Arrangement	Judgement (Discrete)	Judgement (Continuous)
	Act 1	Act 2	Act 3	…	Act n			
1	d_{11}	d_{21}	d_{31}	…	d_{n1}	$(a_1, \ldots, a_n)$	if $\lceil d_i - D_i \rceil > a_i$, then count one overrun event	if $\lceil d_i - D_i \rceil > a_i$, then calculate overrun period
2	d_{12}	d_{22}	d_{32}	…	d_{n2}			
…	…	…	…	…	…			
N	d_{1N}	d_{2N}	d_{3N}	…	d_{nN}			

Case Study

- J60_1 schedule data from Project Scheduling Problem Library (PSPLIB)
- Duration (triangular distribution lower 90% and 150% mode)
- Fixed duration 77 days, 23 critical activities



Case Study

- Simulation with Largest Remainders Method
  - 100 runs
  - ***exponent 0.5***

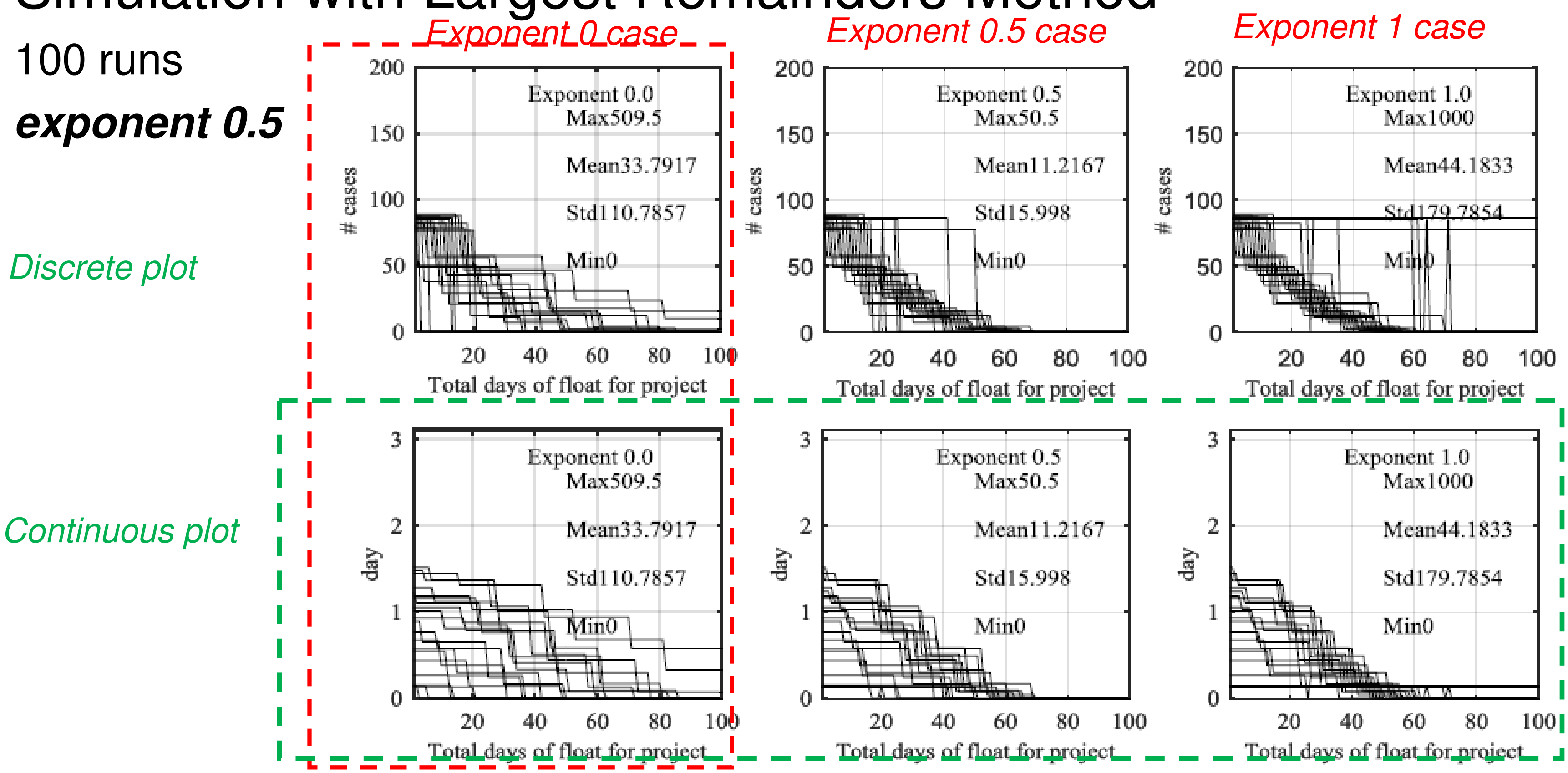


Figure 2: Discrete and Continuous Plots of Simulation Outputs

Case Study

- Simulation with Webster Method
  - 100 runs
  - ***exponent 0.5***

Discrete plot

Continuous plot

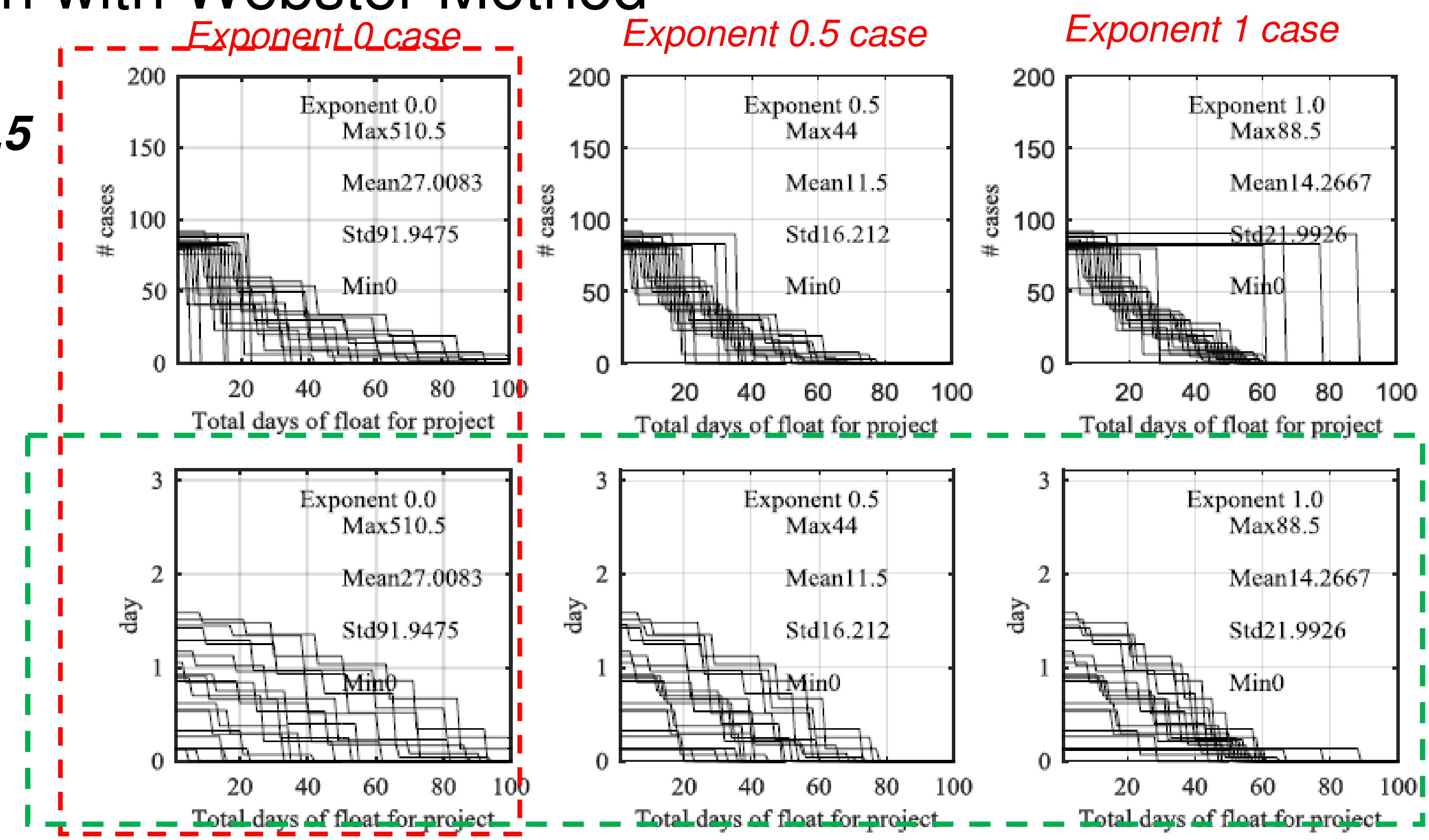


Figure 3: Discrete and Continuous Plots for the Simulation Outputs on Webster

Case Study

- Two advantages for 0.5 exponent
  - The mean of average float overrun is minimum (more economic way to apportion float)
  - Fairest to apportion float for all activities, long and short ones

- For exponent 0, all receive same pre-allocated float – short activities stop overrunning sooner

- For exponent 1, longer activities have advantage and stop overrunning sooner, short ones never receive sufficient float

Conclusions

- Inspired by apportionment methods, this paper integrate them with research on ***who owns float***
- Developed simulation model to test which exponent and with what apportionment method the float pre-allocation will be at an optimum
- Described how to measure the float overrun in discrete count and continuous measure, and represented graphically
- A schedule example from the PSPLIB has been tested and results validate float pre-allocation can be effective and efficient
- Future research will explore and simulate more complex scheduling phenomena, e.g. changes in the critical path due to the randomized durations of activities

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Thank you!

Do you have
any questions?

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