

Who is the Mightiest Avenger?

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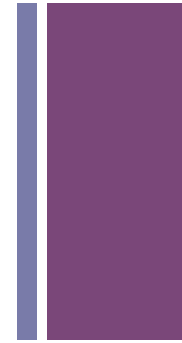
+ Applied probability and the importance of programming

Computing is integral to modern mathematics

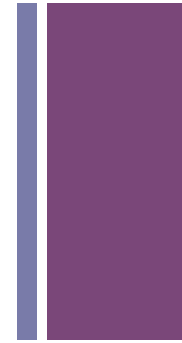
- Core of industrial work is implementation
- Many AP problems can be attacked more quickly (and sometimes more realistically) via simulation
- Programming makes ideas **real**, and imposes discipline on work

And we are fighting a rear-guard action to be part of data science

- Too often DS is portrayed as “model free”



+ Julia

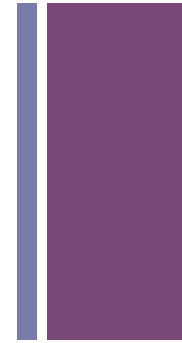


Julia is a (newish) open-source programming language

- Syntax is reminiscent of Matlab
- Purpose is similar to Matlab, R, Python
 - Numerical computing
 - Data science
- Challenges standard intuition about programming paradigms
 - High-performance
 - Without sacrificing productivity

“Julia walks like Python and runs like C”

+ Julia 1.0

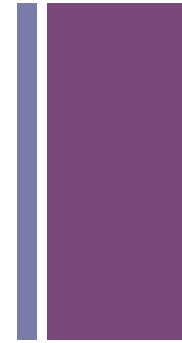


- Julia 1.0 released August 2018 (and 1.1 in May 2019)
 - Stable now, at last!
 - Performance increase from 0.6 -> 1.0
 - 71% time taken for large (surreal) multiplication
 - Performance has always been a crucial motivation for Julia
- I am now using Julia almost exclusively
 - Replaced Matlab (except for teaching)
 - Replaced Perl (except for legacy code)
 - Replaced C
 - Replacing Python (except for certain packages)
- It's not perfect, but it is getting better
 - Biggest limits are in the community size / package availability

+ Why Julia (over Matlab)

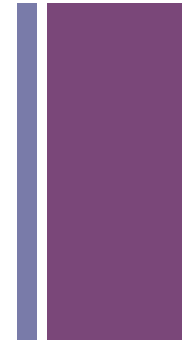
- Open Source
- Modern data structures and idioms
 - Comprehensions
 - Dictionaries (native)
 - Data Frames (package)
 - Don't need to vectorise everything
- Data Types and Multiple Dispatch
 - Example: Distributions package

```
julia> D = Normal(1.0)
julia> quantile.(D, [0.5, 0.95])
Returns [1.0, 2.64]
```
- But it isn't OO (Object Oriented)



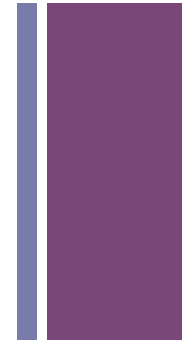
+ Learn by doing

- You don't learn programming languages by reading
- I needed a good project:
 - Simple(-ish)
 - Adds value to Julia community
 - But isn't in the critical pathway, because I am not that good a Julia coder yet
- So
 - Package to do ratings
 - Analysis of a new dataset

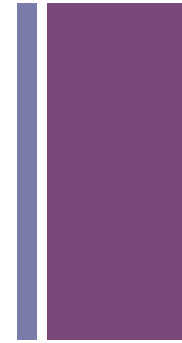


+ (Sports) Ratings

- A common aim is to **rate** teams or players
 - Should be related to **strength** (not just a ranking)
 - Should be objective, based on performance
 - Should take into account the strength of opponents
- There are many systems
 - Linear algebra
 - Massey
 - Colley
 - Eigen-rating
 - Probabilistic
 - **Elo**
 - Glicko



+ Elo Ratings



- Invented by Arpad Elo for rating Chess players
- Elo presumes that the outcome of a contest is random
 - Each player has a strength S_i
 - Player performance is a RV with location parameter = S_i
 - Elo initially used Normal, then Gumbel
 - Winner has higher performance (on the day)
- Ratings R_i are estimates of S_i
 - Elo adopted recursive/iterative update rule
 - Player A v B, outcome is O_{AB} and expected outcome is E_{AB}
 - Outcome probability assumed to be Logistic*

$$R_A' = R_A + K(O_{AB} - E_{AB})$$

* The difference of 2 Gumbels is Logistic

+ Ratings Package in Julia

RatPack.jl

- There are many ratings schemes and variants
- Elo, for instance, has issues
 - Inflation
 - Two-player not multi-
 - Parameter choice (e.g., K)
- Most software for using Elo is only that
 - I want to be able to experiment
- I wanted an extensible, mathematically sound package
- Julia is ideal
 - Numerically fast
 - Good use of memory
 - Easy to program
 - Supportive data structures

+ Ratings Package in Julia

RatPack.jl

- Simple package design
 - Add new ratings system by adding
 - Definition source code
 - Type (for passing parameters)
 - Calculation rule (map outcomes to ratings)
 - A hook in the main package
 - Includes wrappers
 - e.g., iterate over an update rule
 - e.g., simulation of tournaments to feed into tests
 - e.g., scoring and cross-validation
- It isn't quite complete yet, and needs better docs, but I need some nice test cases to play with first

+ The Marvel Cinematic Universe (the MCU)

- Most successful film franchise ever

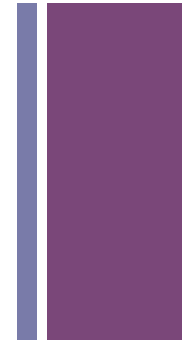
Franchise	Start year	# movies	Box office (US) *
MCU	2008	23	US\$ 8.7 billion
Star Wars	1977	11	US\$ 7.5 billion
James Bond	1963	25	US\$ 5.8 billion
Harry Potter	2001	10	US\$ 3.6 billion
Batman	1989	9	US\$ 2.9 billion

<https://www.the-numbers.com/movies/franchises/sort/World>

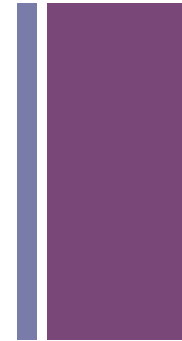
* inflation adjusted

+ MCU and a theory of conflict

- Different genres have different drivers
 - Musicals are driven by songs
 - Dramas are driven by dialogue (most network analysis)
 - Action movies are driven by action
 - A large component of action is **conflict**
- Watched and annotated the entire MCU
 - Data is a set of rows, 1 per “conflict”
 - Conflicts broken down as much as possible to max data
 - Each row has time, nature of conflict, parties involved + winner (or inconclusive), and factors affecting outcome
- Simple (seeming) question: **who is mightiest?**

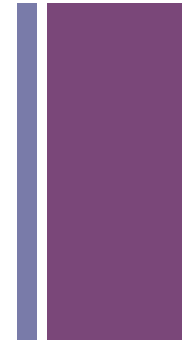
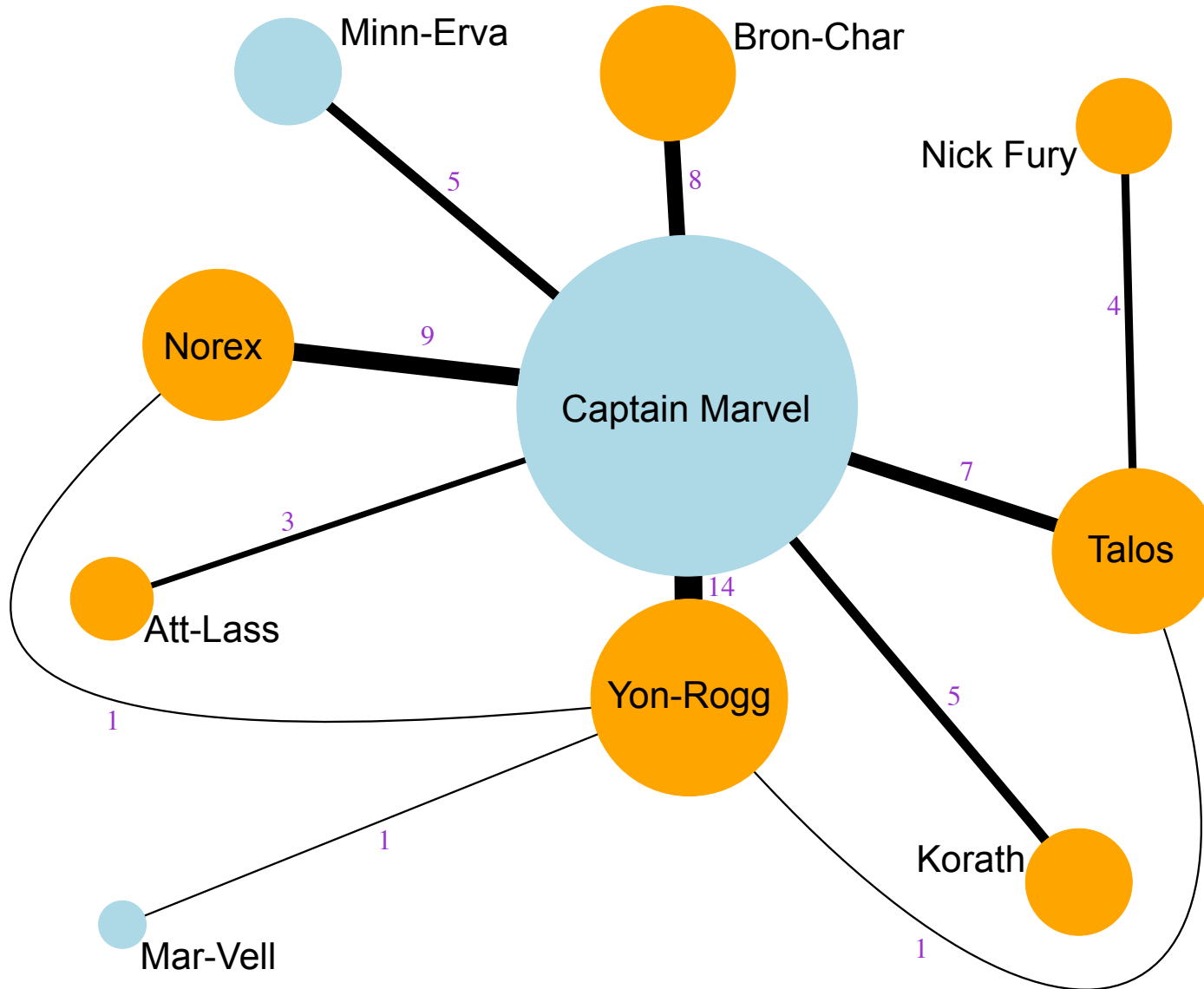


+ Example Data: Captain Marvel



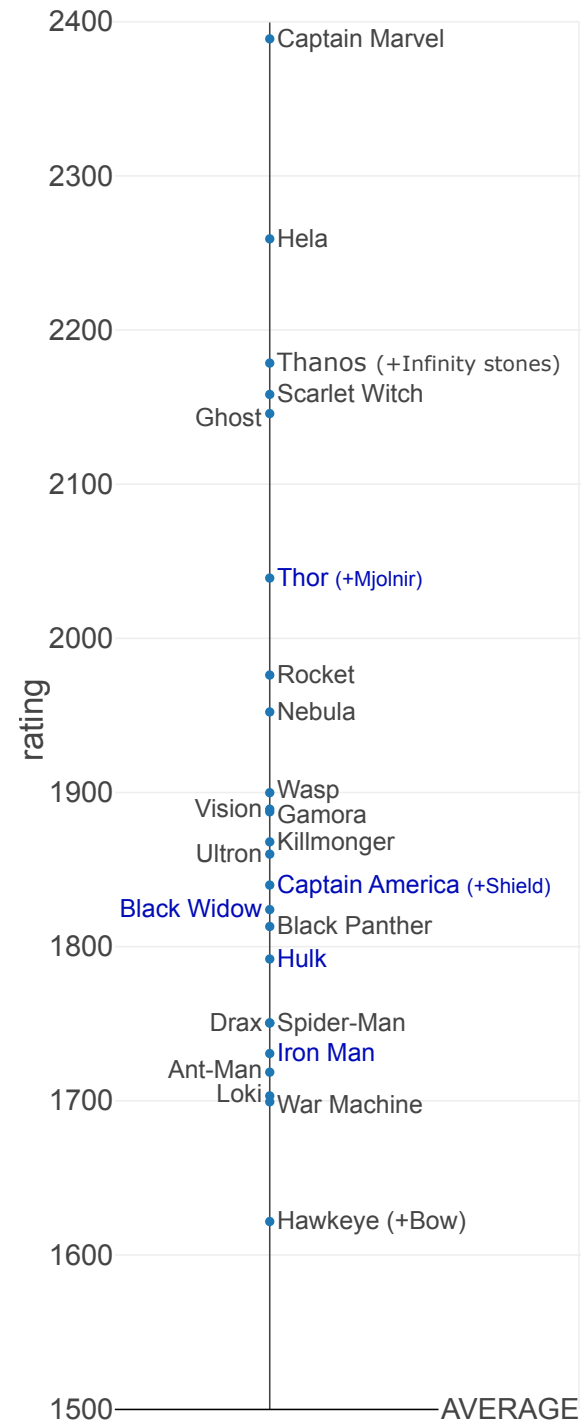
Time	Type of conflict	Party A	F_A	Party B	F_B	Outcome
2.32		Captain Marvel	-2	Yon-Rogg		Yon-Rogg
2.46		Captain Marvel	-2	Yon-Rogg		inconclusive
2.53		Captain Marvel	-2	Yon-Rogg		Yon-Rogg
3.02		Captain Marvel	-2	Yon-Rogg		Yon-Rogg
3.25		Captain Marvel	-2	Yon-Rogg		Yon-Rogg
3.31		Captain Marvel	-2	Yon-Rogg		Captain Marvel
6.22	mental	Captain Marvel		Supreme Intelligence		Supreme Intelligence

+ Conflict Graph (physical)



+ Results

- **MCU conflict data**
 - average = 1500
 - human < 1250
 - “heroic” 1250-1750
 - “super” > 1750
 - “godlike” > 2000
- **Sampled iteration**
 - Resample conflicts
 - Reduce K over time
- **Not bad**
 - Some anomalies
 - Doesn't account for resilience
 - Doesn't account for “team-up” effect



+ Conclusion

- Julia
 - Great new programming language
 - Should replace many older tools
- RatPack.jl
 - Ratings test package as a way to test Julia and learn more
- MCU research is just starting, for some other bits see

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<https://arxiv.org/abs/1906.08403>

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