

Memory Management

Soundness — don't free if needed

Completeness — free when not needed

↳ time — how cpu is taken by M.M. from program

↳ space — how far from optimal the mem use is ↳ % ↳ pauses
↳ absolute

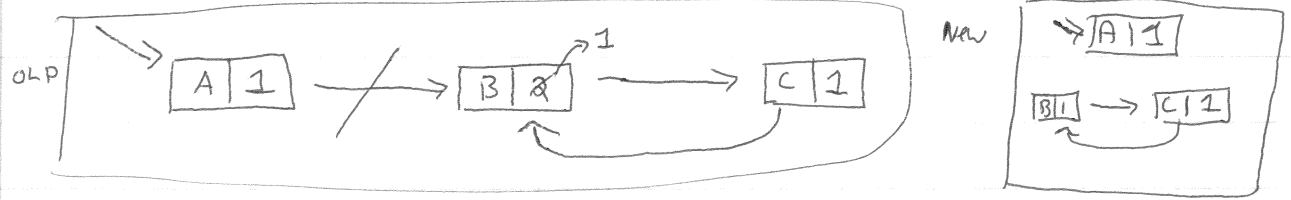
Manual (ie malloc/free) — not sound (mistakes)

— tends to have 2x space + lg n malloc/free

Smart Pointer := ptr + counter — Reference Counting

- malloc initialize the count to 1
- every time you make an alias (ie a copy of the pointer) increment count ↳ retain
- when you destroy an alias, decrement ↳ release
- if after dec, count is 0, then free
- trivial programs retain/release can be soundly inserted

↳ therefore, programmers must insert for some programs ⇒ sound



- cyclic data are incomplete (ie leak memory)
- space := count takes space (25% - 50% depending on structs) (if word)
if byte, 3% - 6% → limits the count → leaks (overflow)
- time := m/f are still lg n + bookkeeping (α to your work)
- cascading deletes → large pauses

Date	Description	Debit	Credit	Balance
1/1/20	Opening Balance			1000.00
1/5/20	Bank of America	50.00		950.00
1/10/20	Wells Fargo	75.00		875.00
1/15/20	Chase	100.00		775.00
1/20/20	AT&T	20.00		755.00
1/25/20	Verizon	30.00		725.00
1/30/20	Comcast	40.00		685.00
2/5/20	Bank of America	60.00		625.00
2/10/20	Wells Fargo	80.00		545.00
2/15/20	Chase	90.00		455.00
2/20/20	AT&T	25.00		430.00
2/25/20	Verizon	35.00		395.00
2/30/20	Comcast	45.00		350.00
3/5/20	Bank of America	55.00		295.00
3/10/20	Wells Fargo	70.00		225.00
3/15/20	Chase	85.00		140.00
3/20/20	AT&T	20.00		120.00
3/25/20	Verizon	30.00		90.00
3/30/20	Comcast	40.00		50.00
4/5/20	Bank of America	50.00		0.00
4/10/20	Wells Fargo	65.00		65.00
4/15/20	Chase	75.00		10.00
4/20/20	AT&T	15.00		5.00
4/25/20	Verizon	25.00		20.00
4/30/20	Comcast	35.00		15.00
5/5/20	Bank of America	45.00		30.00
5/10/20	Wells Fargo	60.00		30.00
5/15/20	Chase	70.00		40.00
5/20/20	AT&T	10.00		30.00
5/25/20	Verizon	20.00		10.00
5/30/20	Comcast	30.00		20.00
6/5/20	Bank of America	40.00		20.00
6/10/20	Wells Fargo	55.00		35.00
6/15/20	Chase	65.00		70.00
6/20/20	AT&T	15.00		55.00
6/25/20	Verizon	25.00		30.00
6/30/20	Comcast	35.00		0.00
7/5/20	Bank of America	45.00		45.00
7/10/20	Wells Fargo	60.00		105.00
7/15/20	Chase	70.00		175.00
7/20/20	AT&T	15.00		160.00
7/25/20	Verizon	25.00		135.00
7/30/20	Comcast	35.00		100.00
8/5/20	Bank of America	40.00		60.00
8/10/20	Wells Fargo	55.00		5.00
8/15/20	Chase	65.00		30.00
8/20/20	AT&T	10.00		20.00
8/25/20	Verizon	20.00		0.00
8/30/20	Comcast	30.00		30.00
9/5/20	Bank of America	35.00		35.00
9/10/20	Wells Fargo	50.00		15.00
9/15/20	Chase	60.00		45.00
9/20/20	AT&T	10.00		35.00
9/25/20	Verizon	20.00		15.00
9/30/20	Comcast	25.00		10.00
10/5/20	Bank of America	30.00		20.00
10/10/20	Wells Fargo	45.00		25.00
10/15/20	Chase	55.00		30.00
10/20/20	AT&T	10.00		20.00
10/25/20	Verizon	20.00		0.00
10/30/20	Comcast	25.00		25.00
11/5/20	Bank of America	25.00		0.00
11/10/20	Wells Fargo	40.00		40.00
11/15/20	Chase	50.00		90.00
11/20/20	AT&T	10.00		80.00
11/25/20	Verizon	20.00		60.00
11/30/20	Comcast	25.00		35.00
12/5/20	Bank of America	20.00		15.00
12/10/20	Wells Fargo	35.00		20.00
12/15/20	Chase	45.00		35.00
12/20/20	AT&T	10.00		25.00
12/25/20	Verizon	20.00		5.00
12/30/20	Comcast	25.00		20.00
1/5/21	Bank of America	15.00		5.00
1/10/21	Wells Fargo	30.00		15.00
1/15/21	Chase	40.00		35.00
1/20/21	AT&T	10.00		25.00
1/25/21	Verizon	20.00		5.00
1/30/21	Comcast	25.00		20.00
2/5/21	Bank of America	15.00		5.00
2/10/21	Wells Fargo	30.00		15.00
2/15/21	Chase	40.00		35.00
2/20/21	AT&T	10.00		25.00
2/25/21	Verizon	20.00		5.00
2/30/21	Comcast	25.00		20.00
3/5/21	Bank of America	15.00		5.00
3/10/21	Wells Fargo	30.00		15.00
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