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Android MGLRU Evaluation

Kalesh Singh (kaleshsingh@google.com)



Testing Methodology

Test

- App cycle tests
- ~30 apps
- Pseudo random order
- 200 iterations

Device (Pixel 6 Pro)

- 8 cores
- 12GB RAM
- 3GB ZRAM

Results





App Launch Time

- Overall app launch times decreased **~6.60%** with MGLRU enabled.
- The ratio of hot starts to other types also improved with MGLRU.

App Launch Ratios	Baseline	MGLRU
Hot to Cold	3.31	3.82
Hot to Warm	16.87	19.78
Warm to Cold	0.20	0.19



App Launch Time

- Not only more hot starts, but the launches are also faster.

Avg App Launch Latencies	MGLRU
Hot	-3.02%
Warm	-3.86%
Cold	-0.29%



Number of Kills

- MGLRU showed less overall kills compared to the baseline

Kills	MGLRU
AMS	10.56%
Lmkd	-83.56%
OOM	>800 MGLRU (0 Baseline)
Total	-8.04%



Working Set Defaults

- Working set defaults decreased significantly with MGLRU enabled

Working Set Defaults	MGLRU
Anon	-64.95%
File	-81.74%



Reclaim CPU Usage and Efficiency

- kswapd CPU usage decreased by **54.50%** with MGLRU enabled.
- MGLRU also saw improved reclaim efficiency

Reclaim Efficiency	Baseline	MGLRU	Delta
Kswapd	32.60%	57.21%	24.61%
Direct Reclaim	43.02%	42.91%	- 0.11%
Anon	16.74%	40.06%	23.31%
File	55.02%	69.66%	14.46%



Direct Reclaim Latency

- MGLRU showed a **81.10%** decrease in the number of direct reclaims
- But total time spent in direct reclaim increased by **94.27%**.

Direct Reclaim Latency Count		MGLRU Count
Low Lat	(< 5ms)	-87.48%
Mid Lat	(5ms to 50ms)	-40.72%
High Lat	(50ms to 500ms)	69.12%
Super High Lat	(> 500ms)	513.51%



Increasing Swap Size

- Deltas are comparing MGLRU to upstream page reclaim (baseline) with the same ZRAM size.

	3GB ZRAM	6GB ZRAM
App Launch Time	-6.60%	-7.53%
Direct Reclaim Efficiency	-0.11%	+2.74%
Direct Reclaim Hits	-81.10%	-83.92%
Direct Reclaim Stall Time	+94.27%	+52.76%



No Swap

Test

- App cycle tests
- ~30 apps
- Pseudo random order
- 100 iterations

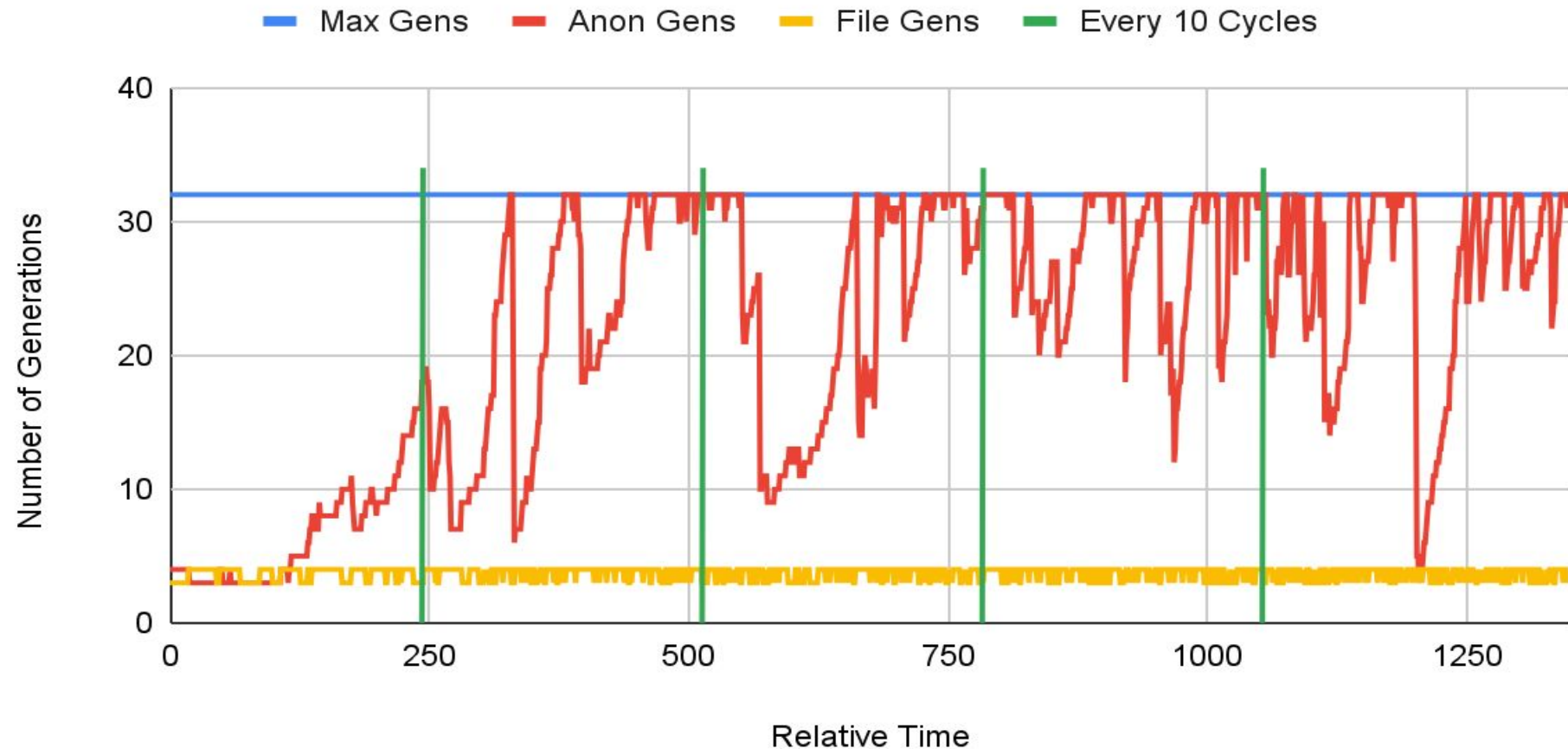
Device (Pixel 6)

- 8 cores
- 8GB RAM
- 6GB ZRAM

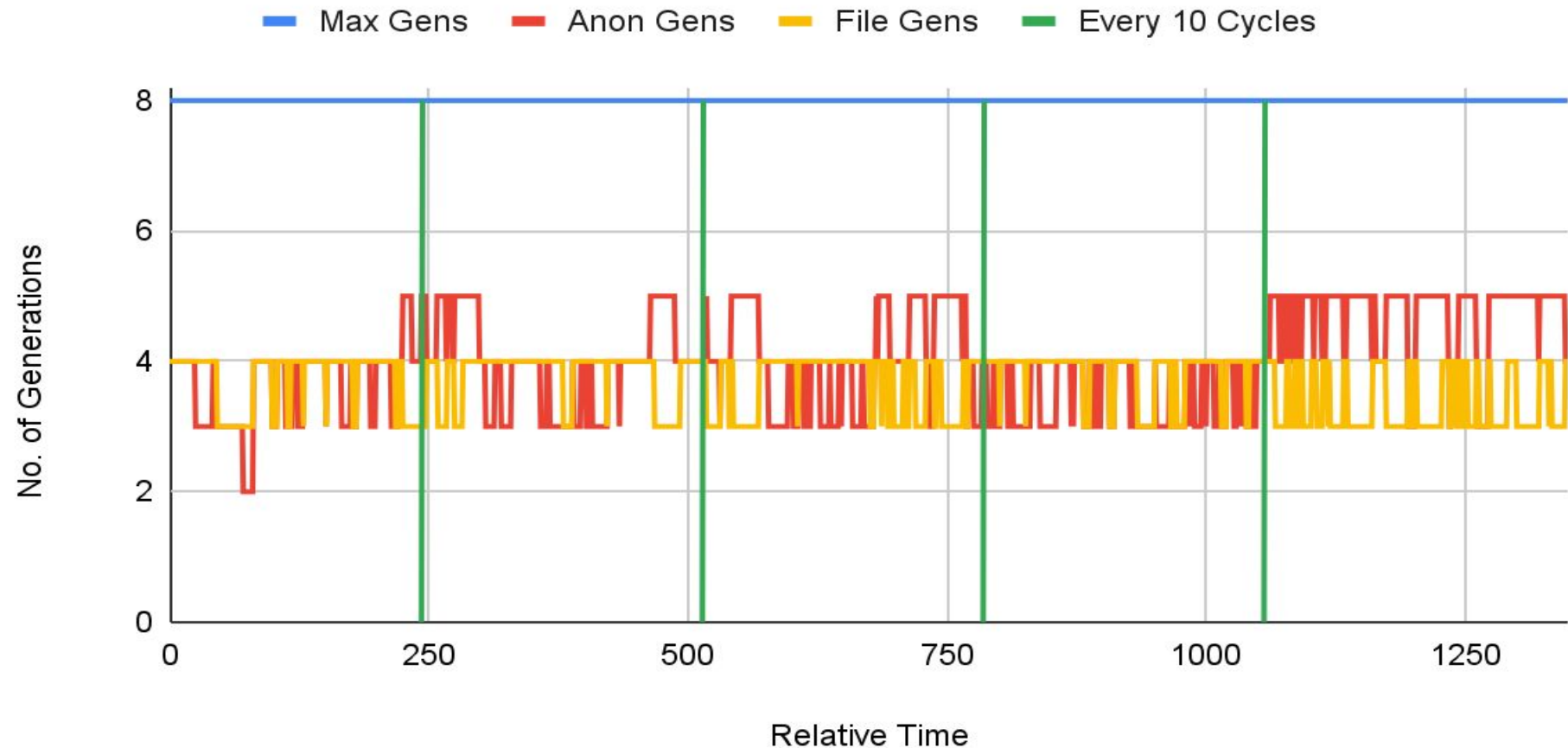
Results

- Overall app launch times decreased **-47.10%** with MGLRU enabled
- Direct Reclaim Efficiency improved from **5% to 43%**
- Kswapd Reclaim Efficiency improved from **20% to 63%**
- **-15%** less overall kills
- **-98%** file working set refaults
- **-99%** Direct Reclaim stall time
- **-99%** Direct Reclaim hits
- **-92%** kswapd CPU usage
- MGLRU does better at preventing thrashing

Number of Generations Increased to 32



Number of Generations - Anon Gen Threshold



Questions

How can we improve the direct reclaim latencies?

