



Linux on Flash

*The Benefits & Pitfalls of Flash
Memory in*

Open Source Environments

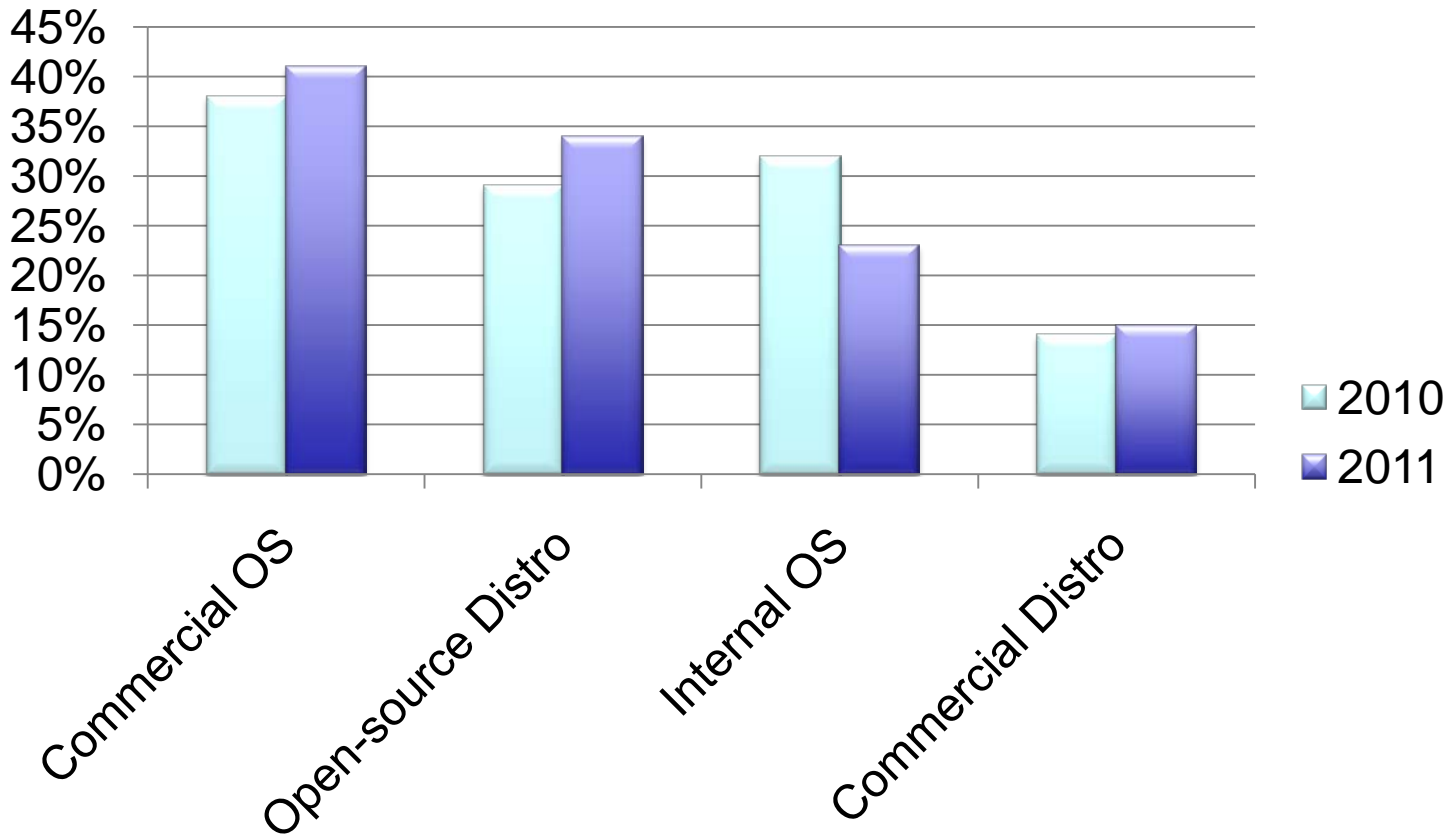
Thom Denholm - Datalight



Agenda

- Growth of Linux and Flash Memory
- Options for Managing Flash
- Factors to Consider
 - System Boot vector
 - Discard Interface
 - Design Upgrades
 - Support

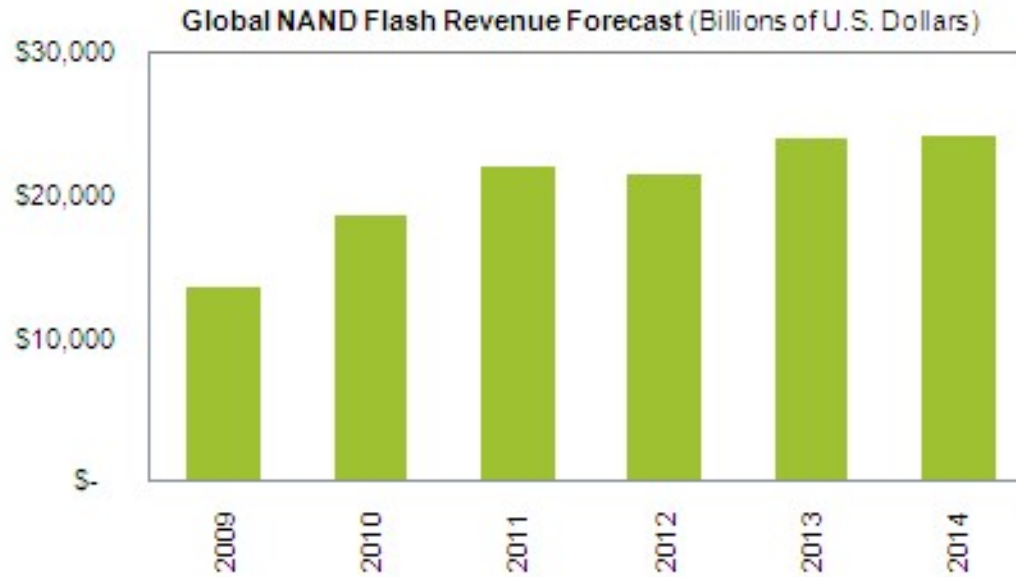
Growth of Linux



Source: EE Times Embedded Market Study 2011

Growth of Flash Memory

- 2011 - \$22 billion; 19.3 billion gigabytes



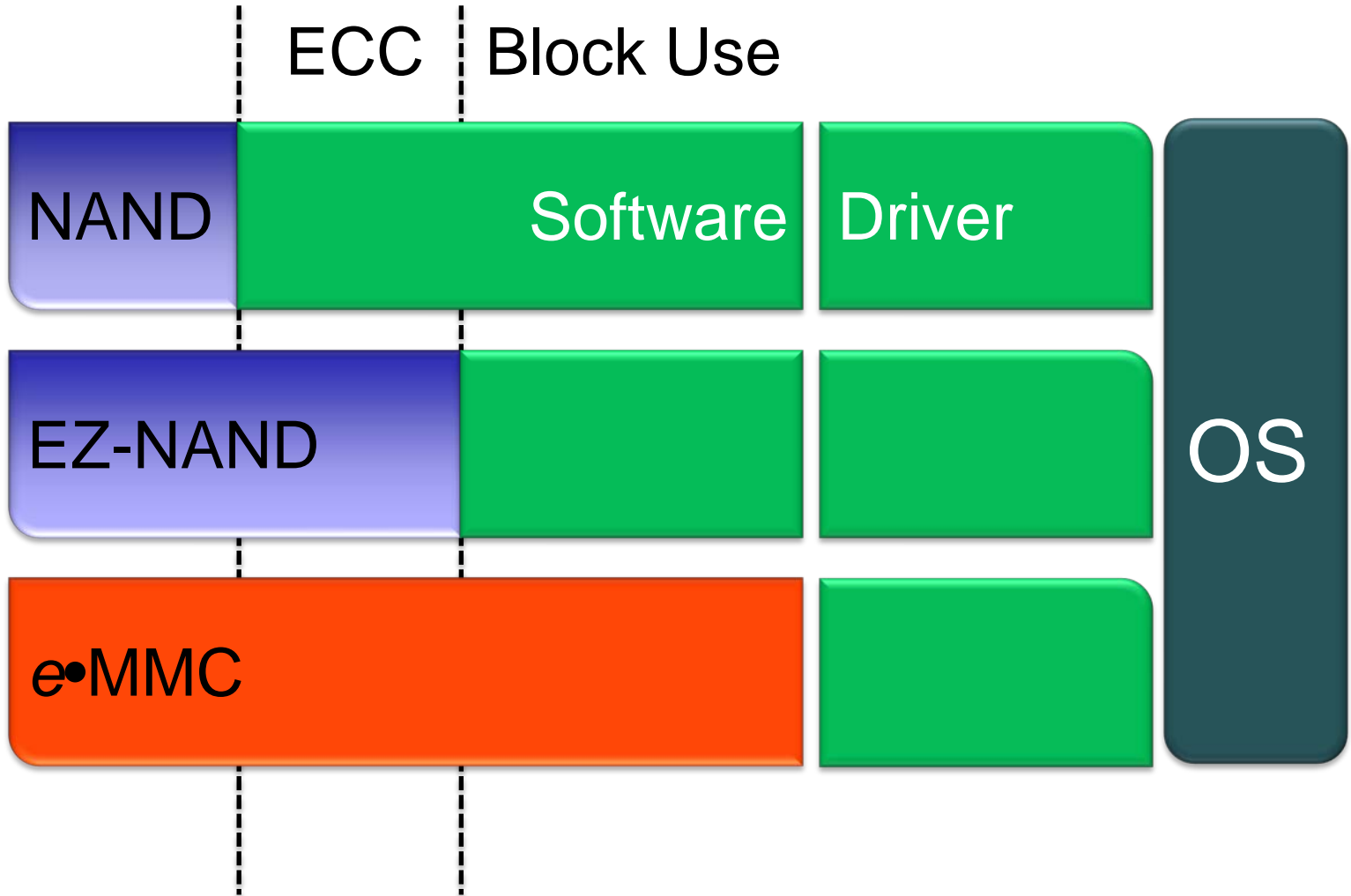
Source: IHS iSuppli Research, Jan. 2011



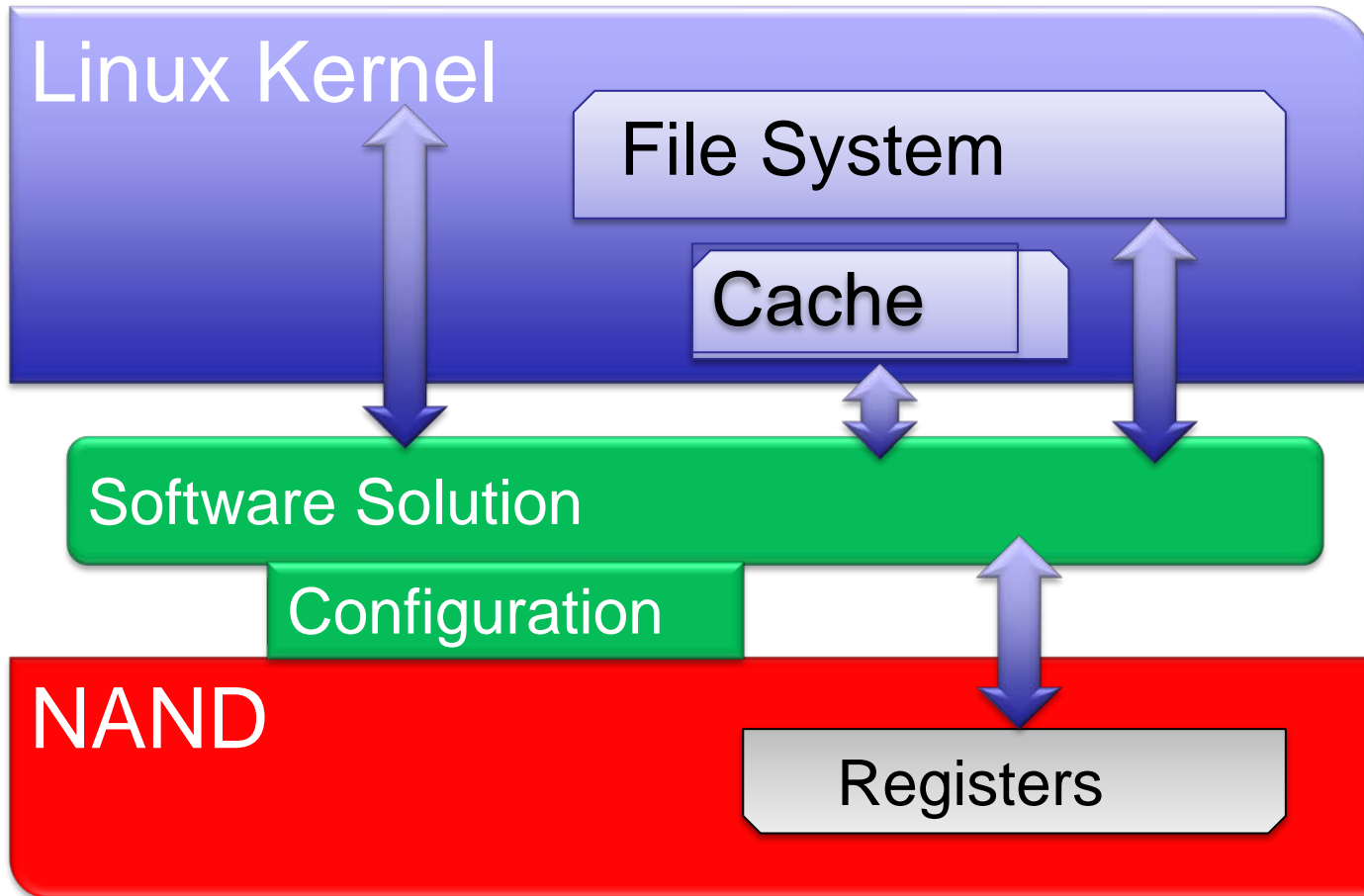
Challenges of Working with Flash on Linux

- Flash must be “managed”
- Driver required for more than basic functionality
- Flash File System (YAFFS, JFFS2, UBIFS)

Flash Management

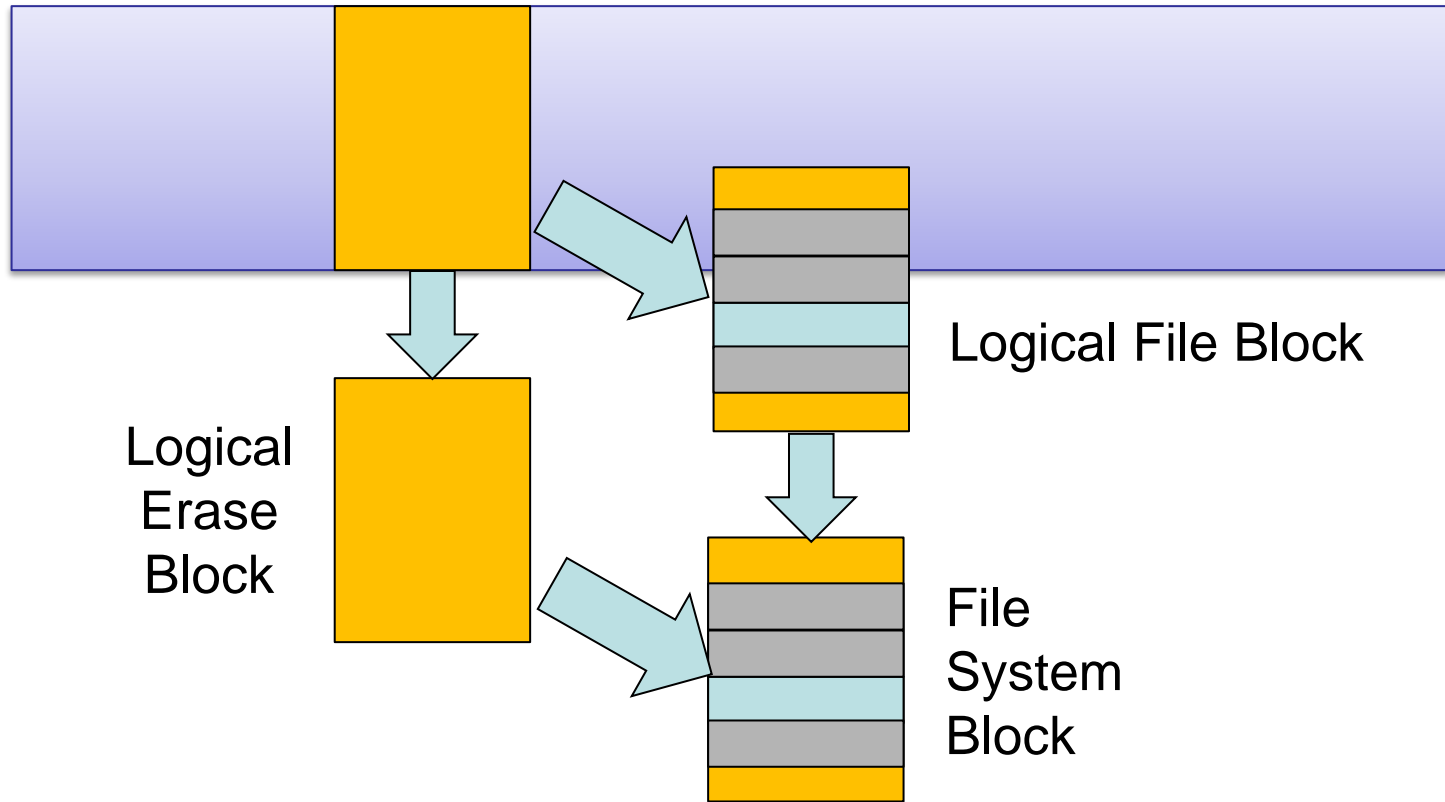


Software alternatives



Erase Units to Disk Sectors

Physical Erase Block





Pitfalls

- Write Amplification
- ECC - Bad Blocks
- Wear Leveling



Wear Leveling Effectiveness – Dynamic Only

66	5504	17	1	103	1	57	1	75	1	60	5440	1	1	74	1
5488	1	5472	1	5235	5339	1	1	5389	1	23	5455	1	5353	1	39
27	1	52	1	161	47	1	95	1	27	81	65	1	62	1	5496
5463	1	5413	1	166	5362	1	5583	1	5387	69	1	5403	1	253	1
5534	1	5410	1	1	184	64	1	5404	1	72	3	63	5429	1	77
13	1	1	46	5469	1	1	43	1	66	1	5375	1	16	5481	1
1	136	1	23	1	169	1	5436	1	5420	5291	1	7	1	5205	5338
1	2	92	172	5431	121	5480	139	305	1	41	242	1	32	172	39
5412	5186	1	38	91	5407	88	32	126	112	5313	32	47	2	23	1
1	1	1	837	1	1	1	1	87	5355	5359	1	1	4	1	1
1	155	5352	1	1	1	1	40	1	1	1	1	99	1	1	1
2	39	1	86	5265	1	111	1	26	5401	1	1	35	1	1	1
22	51	1	5291	1	32	5490	1	55	1	40	1	100	1	1	1
70	5404	1	554	1	5264	5374	1	121	1	5321	5348	1	84	1	1



Uneven usage! Only dynamic data is wear leveled



Wear Leveling Effectiveness – Complete

2252	2163	1573	1508	1944	2167	1869	1590	2261	2188	2233	1922	2182	1768	1601	1598
2171	1610	1912	2058	1598	1643	1753	2211	2042	2151	1597	1554	1624	2139	1541	1756
2302	1648	1542	1586	1683	2294	1589	1722	1673	2167	1991	1579	2333	2208	1573	2055
1702	1763	1524	1944	2197	1656	1922	1544	1664	1551	1541	2174	2191	1889	2193	2168
1812	2230	2184	2206	1707	2124	2163	1531	2184	2164	1988	1658	1591	1613	2225	2225
2167	1549	1548	1669	1593	2000	2234	2242	1616	2149	2213	2228	2224	1592	1539	1719
1530	1542	2217	1673	1572	1717	1542	1536	2190	1614	1634	1631	2221	1512	1578	1509
2161	1673	2259	1563	1703	2038	2245	2255	1722	2248	1575	1524	2249	2207	1666	2181
2194	1601	2240	1822	2163	1526	2204	2163	1687	2256	1593	2146	1627	1950	2139	2181
1884	1536	2185	2289	2117	2240	1851	1510	2292	1937	1568	1623	2308	2178	1568	2154
1638	2176	1703	1625	1608	1520	2142	2200	2161	2185	2214	1774	1590	2086	1529	2159
2164	2130	1521	2162	1651	2246	1620	1823	1871	1511	2329	1639	1522	1566		
1540	1736	1696	1513	2249	2366	1909	1517	2194	1608	2165	1628	2216	192		
1652	2198	1591	1543	1843	2205	1549	1533	2150	1553	1580	2165	1522	156		



Underused

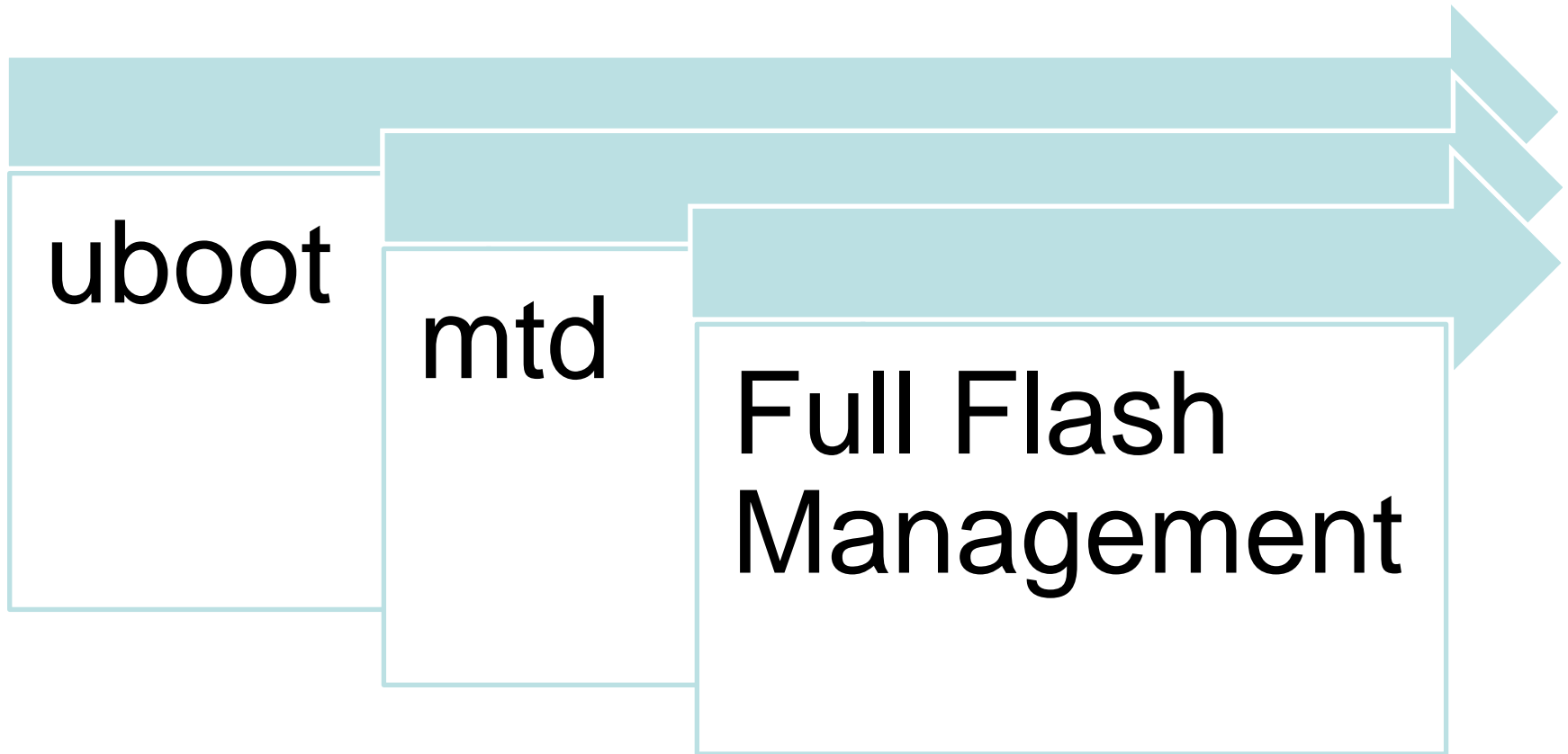
Optimal

Overused

Nearly uniform wear across static & dynamic data

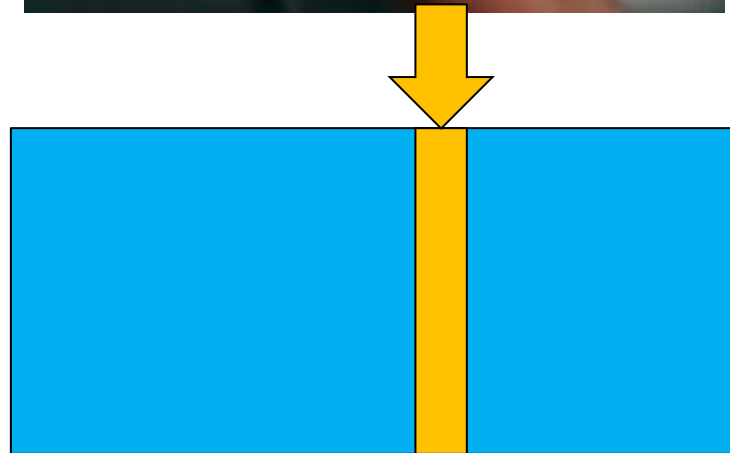


FACTORS TO CONSIDER

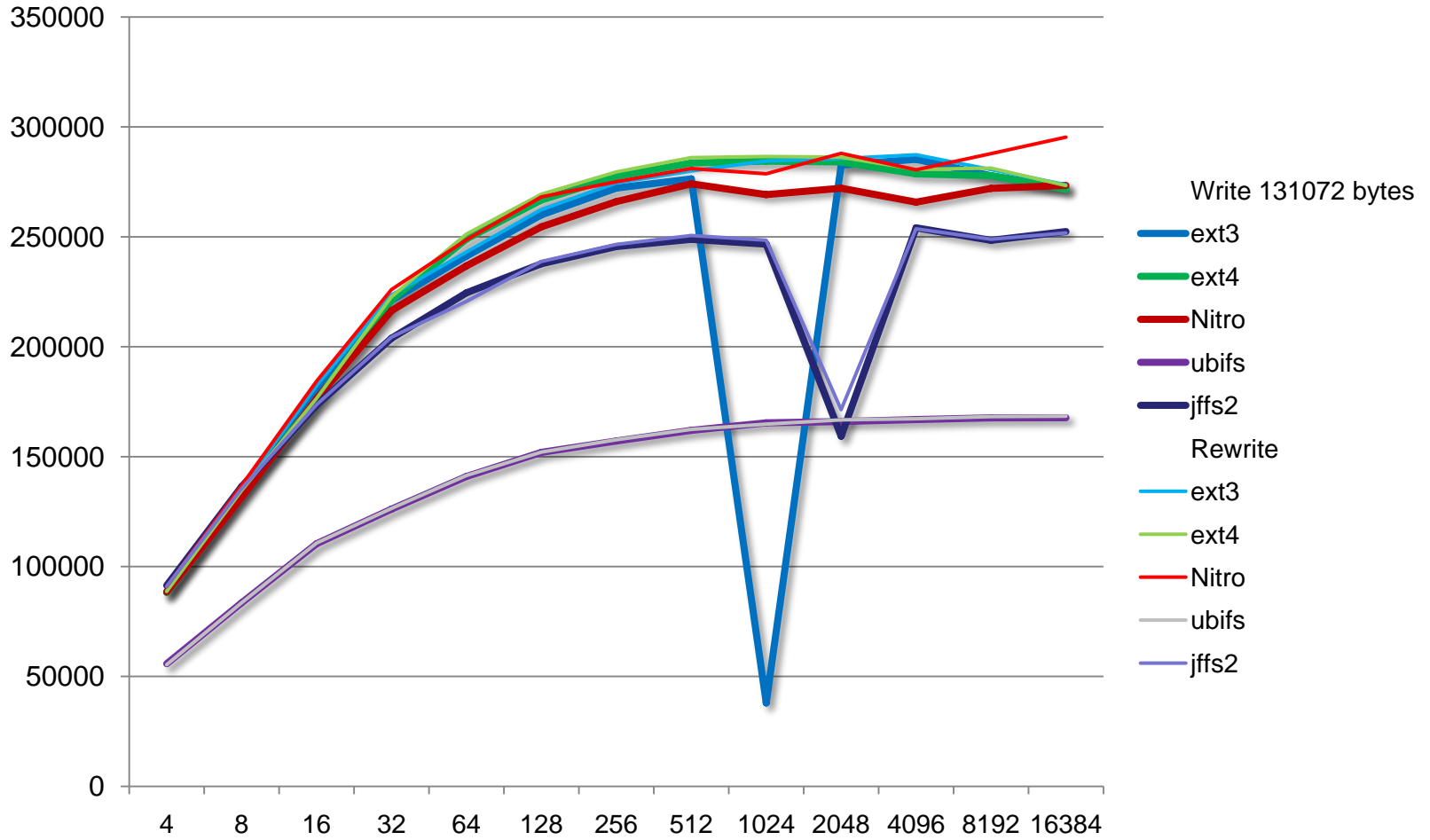


Discard interface

- File system delete
- Hardware notified
- Saves flash life, wear leveling



Testing





File System Connection

Linux Kernel

Flash File System

NAND



File System Connection

Linux Kernel

New File System

eMMC

Design Upgrades

- Flash Part End-of-Life
- Kernel updates

Linux[™]
3.0.0.0 RC1



- Evaluation
- Field Failures
- Flash Image Tools

