SIXTEEN:NINE

16:9 SPECIAL REPORT

SMART DIGITAL SIGNAGE DISPLAYS

FALL 2018 UPDATE

PRODUCED BY VERTICAL MEDIA CONSULTING GROUP, INC.
IN COLLABORATION WITH

signageOS

INTRODUCTION

DAVE HAYNES
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OCTOBER 2018

About 18 months ago, Sixteen:Nine looked at the state of smart displays and raised the question of whether digital signage displays with embedded System on Chip (SoC) players inside represented the future path for the industry.

In early 2017, almost every sign pointed to widespread adoption. By late 2018, that adoption is happening.

All of the leading professional display manufacturers now ship digital signage displays with some sort of embedded media players – though almost all of them do it a bit differently.

Those display companies, and the software companies that have adopted or tuned their platforms to work with embedded players, are all reporting smart displays are very significant and growing parts of their businesses.

It represents 50% or more of the business for some well-established software companies, and numerous companies contacted for this report reported steadily growing percentages of their business migrating away from PCs and dedicated player boxes to all-in-one displays.

In 2014-15, rollouts were counted by the dozens or 100s. Now there are numerous networks on SoC that number in the 1,000s, and individual sites (like sports and entertainment venues) using 100s.

When SoC came on the market, it was reasonable for companies to be sceptical about the long-term commitment of the display manufacturers. They have been known to introduce products with considerable fanfare, and then drop them. The early adopters benefited from the marketing muscle of these display co's, but had to commit a lot of time and resources to underpowered, little understood products that kept changing on them.

Five years on, SoC is a well-established mainstream product customers are asking for, and the great majority of the market-leading digital signage solutions providers have an offer built around smart displays.

This updated report looks at the current state of usage, and how and why the market is going smart and moving away from the traditional PC-based media players that dominated the first two decades of digital signage. Samsung says 60% of its digital signage display business is now SoC-based, though a qualifier would have to be that not all smart displays that ship get used as smart displays.

This updated report was largely triggered, encouraged and supported by signageOS, a Prague-based startup that provides a unification platform for digital signage devices, remote management and content delivery. Some of this report reflects that company's now-deep experience working with the many different display platforms and the CMS software companies using them.

Their work, for this report, includes extensive testing and analysis.

I could have sought sponsors for this updated report, but chose instead to do this with absolute independence. I have current or previous business ties to various display and software companies through the years, and signageOS, by necessity, works with dozens of companies. But those ties have not influenced this report.

Senior people at numerous display and software companies kindly provided their insights on how they are using embedded players, and how the marketplace is responding to and using these smart screens.

Their candid points of view were critical to getting a clear sense of where the market is at.

INTRODUCTION

STAN RICHTER
CEO, SIGNAGEOS INC.

OCTOBER 2018

The goal behind our involvement with Sixteen:Nine on SoC report is to provide the industry with a useful resource and understanding of the current state and progression of SoC.

Our company's long-term focus on SoC technology has provided us with the knowledge and expertise to assist in the creation of this report. Regardless of our standing with SoC displays, the objective here is to provide unbiased research and honest opinions for the whole industry.

We greatly appreciate everyone that provided information and opinions for this report and of course, Sixteen:Nine's Dave Haynes for letting us assist in its creation.

I hope you'll enjoy it.

The **signageOS** platform stands to help CMS companies with the wide landscape of displays and operating systems in digital signage. After years of testing and developing we have acquired the knowledge to efficiently build and maintain native applications for SoC displays, different operating systems and many external players. Our aim is to simplify digital signage by removing hardware/software compatibility issues that frustrate many CMS companies and force end-users to lock into one solution. signageOS is here to ensure that the industry has its own standard API for display and player communication regardless of operating system or display brand.

SIXTEEN:NINE

CONTENT

A BRIEF HISTORY OF SMART SIGNAGE DISPLAYS

Digital signage displays with built-in media players trace back more than a decade, with manufacturers incorporating thin Intel-based PCs into slots on the backs of LCDs. Intel even developed a specification – Open Pluggable or OPS – that was (and is) a reference design for slot-loaded media players for commercial displays.

However, OPS displays added more cost and market-place adoption has been relatively low. That could be attributed to the added cost of OPS design, and how PCs and digital signage media players have grown small enough to easily tuck in behind displays, without needing dedicated slots.

Integrated panels with SoCs are different. These are, effectively, commercial versions of smart TVs, or thought of another way, GIANT tablets, without touch-screens. The technology that makes these screens "smart" is the same technology used in smartphones, tablets and a steadily growing range of smart devices – from speakers to refrigerators. They are attractive to the signage market because they offer computing and graphics capabilities on tiny devices, at very low costs (because of mass manufacturing).

The products are different, but a smart digital display shares a lot of electronics DNA with smart TVs coming from the same company. "Traditional SoC manufacturers are essentially re-using their consumer platforms, which are mainly optimized around streaming," suggests Ann Holland, VP Marketing for media player manufacturer BrightSign.

The first smart displays, with pre-installed Android software, started showing up at trade shows in 2011-2012, marketed by tiny and unfamiliar manufacturers from Taiwan and China's Shenzhen electronics hub.

It was not until early 2013, however, when Samsung announced its Smart Signage program, that the digital signage ecosystem started hearing about and seriously looking at the idea of SoC displays.

The first generation did little more than playback jpegs and basic video because of their limited processing and graphic power. In plain terms, they weren't very good at digital signage, and a lot of the companies that tried to work with the displays, backed off.

Adoption among those software partners was also limited by skepticism about the manufacturer's long-term commitment to a nascent product and platform, and the somewhat proprietary, restrictive applications that developers had to work within.

A second generation with faster processors and more software capability followed a year later, and by 2014, Korean rival LG launched a rival product, running LG's webOS for Signage.

Both Panasonic and Philips debuted their own SoC display lines in 2016, as did Viewsonic and Turkish display manufacturer Finlux (Vestel). In early 2017, Sharp and Toshiba also introduced SoC displays.

Sony has networked connected displays that have an HTML5 player embedded, and support Android TV, but do not have development platforms for CMS companies.

NEC is the only major display manufacturer outlier – marketing Open Pluggable displays but also now actively marketing a single-board computer module that fits in the back of select NEC panels. That little trap door on the back of NECs uses the $45 Raspberry Pi computer – a product developed as a low-cost computer for schools, but much more widely adopted in business because it offers power at very low cost, and has a massive, global open source community steadily pushing its capabilities.

Touch screen manufacturer Elo includes in its lineup SoC displays for Android, and Windows, and an optional, Intel-based slide-in compute module for its large displays.

SOC DISPLAY BASICS

The typical kit of parts for digital signage projects includes a PC or other media playback device, like a set-top box, that plugs by cable into the back of the display. With System on Chip (SoC) displays, the playback device and its cables are replaced with an integrated circuit that puts all the typical components of a computer on a single chip, mounted inside the enclosure of the display.

SoC devices have been around for many years, used primarily in the embedded systems market for industrial applications. In recent years, SoC devices have been behind the rise of smartphones and tablets – built with enough processing power to run operating systems like Android, iOS and Windows Mobile.

SoC display devices have much in common with the devices used in consumer-grade "smart TVs" and, in fact, smart TVs pre-date the arrival of commercial-grade SoC displays on the digital signage market in 2013.

Most of the SoCs on the market run some version of Android or Linux, which is the foundational operating system for Google's Android OS. Samsung had used a proprietary operating system in its early Smart Signage models, but has now standardized on its own Linux-derived operating system, called Tizen.

LG uses its own Linux-derived webOS, which was originally developed as a mobile OS, and is used on its Smart TV platform.

The other manufacturers are not running their own proprietary digital signage platform. Instead, they use contemporary versions of the Android operating system – essentially the same OS used by a larger percentage of the smartphone market globally.

There are very few SoC displays running Windows, and none running on Apple's MacOS. The Windows units are not embedded at the factory level, but come as snap-in modules that run an embedded Windows OS.

KINDA SORTA SOC

Companies such as BrightSign argue that System on Chip should not be entirely defined as displays that have embedded media players fully inside of commercial displays. The company has a single-board media player module that – like Raspberry Pis and embedded Windows – can be added to displays. Several display partners are working with BrightSign. The Silicon Valley company, a spin-out years ago from Roku, says it has already shipped 28,000 of these modules.

Taiwan's IAdea argues its all-in-one displays are SoC-based, and like BrightSign, goes to market as a media player company, not a display company.

LOWERED COSTS, BUT NOT FREE

One of the big value propositions used in marketing these smart displays is that the capital cost of a media player is removed from the equation, along with the costs of things like cables and power supplies.

That's true, but the smarts embedded in smart displays are not free. Those smart modules embedded inside the displays are built into the overall cost of the commercial panels. Estimates vary, but that cost (depending on the power and "newness" of the processor) is probably $50-$100. That additional cost brings it in line with the cost of some external media playback devices, notably Android-based set top boxes and HDMI sticks.

However, using a Samsung or LG commercial display with an external device means it is likely you are paying for both an external player and that internal one, since most of those companies' commercial signage displays start as smart displays.

It's changing as adoption rates escalate quickly, but for a long time, many "smart" displays that shipped never had their embedded smarts used – acting instead as dumb display monitors.

Where there can definitely be lowered costs is in installation, as fully self-contained units that only need a power plug go up faster. Streamlined installs can mean lowered deployment labor costs.

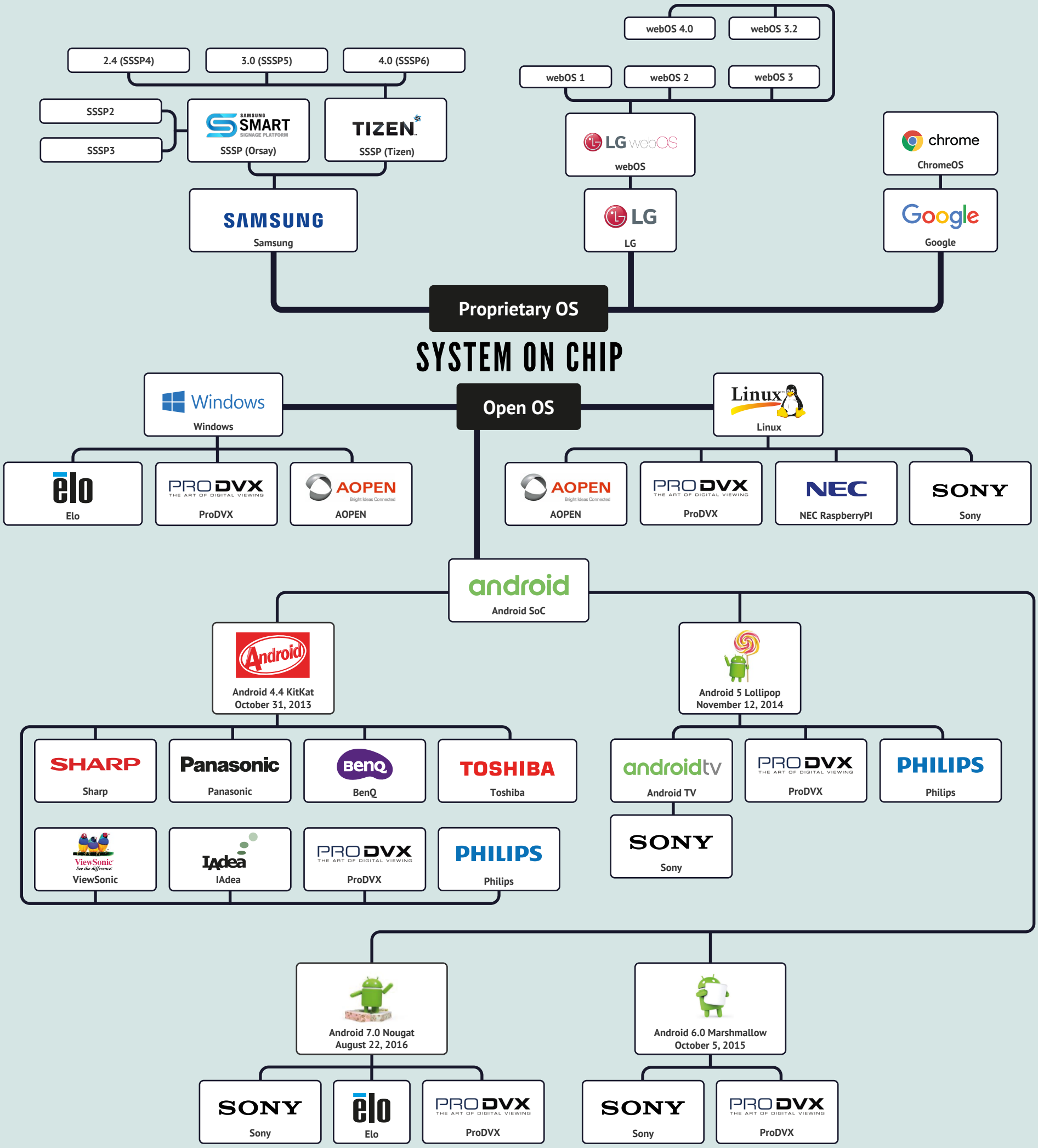
"I think an SOC solution just make sense," says Guy Avital, CEO of the LA-based CMS software company UCView. "It is simple, and removes so many failure points we needed to deal with when using regular PC-based players."

"Deploying SOC saves 15% of the deployment CAPEX cost, and 20% of the OPEX cost," adds Jerome Moeri, CEO of Swiss-based Navori.

"I'm not sure I see the future as being anything other than SoC," says Nick Fearnley, CEO of UK-based Sign-Stix.

"I hope we see developers like us getting the access we need to make the panels really shine," he adds. "IOT is now a recognised term and DS SoC solutions really do form a part of that. I think we'll see more of what we've been working on – the use of SoC for processing data that is NOT for display, there's already a huge amount of processing power available to clients - for free - on existing SoC solutions. I think CMS's will evolve quite dramatically to enable business logic to be managed and deployed, we're seeing the start of this now."

WHO'S DOING SOC – HW MANUFACTURERS



WHO'S DOING SOC – CMS SOFTWARE COMPANIES

When the first generations of SoC displays came on the market, only a handful of companies allocated substantial resources to SoC to fully integrate their software platforms. Another, relatively small group of companies "got it to work" with the simplified, Web-based versions of their product that use HTML5 and cross platforms relatively easily.

Now there are scores, probably 100s of companies, globally, offering solutions that fully run on SoC. Often, these companies have developed flexible solutions that have been designed to work across multiple SoC manufacturers – instead of being restricted to just one.

"End-users already expressed a strong desire for CMS companies to manage mixed player hardware/SoC networks. This is highly demanding for CMS companies, whose developers have to keep up with never SoC OS versions that are constantly being released," says Stan Richter, CEO of signageOS.

The largest company expressly in the digital signage software and solutions business – Stratacache – does not work with smart displays through its mothership product, Activia, or through its acquired companies, which include Scala. CEO Chris Riegel has concerns about the security of the Korean smart displays, in particular, and also openly wonders about why software companies would develop partnership companies with display companies that overtly market their own CMS platforms.

Other companies say they just don't think embedded players match up with separate media playback device capabilities.

"We see the capabilities being limited," adds the GM of a US-based CMS software firm that has looked at SoC, and opted not to dive in. "We want to control the whole stack in the loop between client and server-side."

However, many companies say smart displays are entirely suitable for many to most digital signage demands.

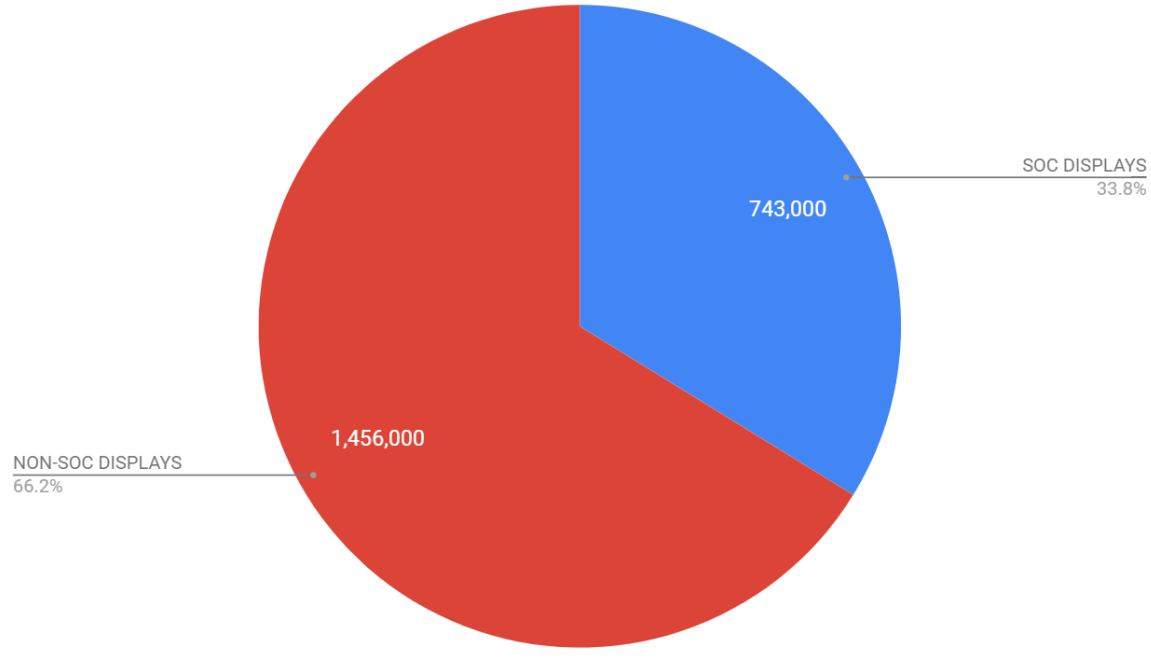
Theo Wieckardt's Dutch software firm, Gauddi, was an early adopter. "SoC has come a long way and Gauddi has worked in close cooperation with LG for webOS and Philips, for Android, from the first product introductions. Nowadays, any push-back we might have had in the beginning has changed into a SoC-first approach, which is firmly supported by our team."

In certain respects there are at least two camps among software companies. Some companies have made SoC their primary focus and hardware platform, and developed to a specific manufacturer's set-up. Others, like PingHD and Signagelive, have solutions that work across numerous hardware platforms.

SOC BY THE NUMBERS

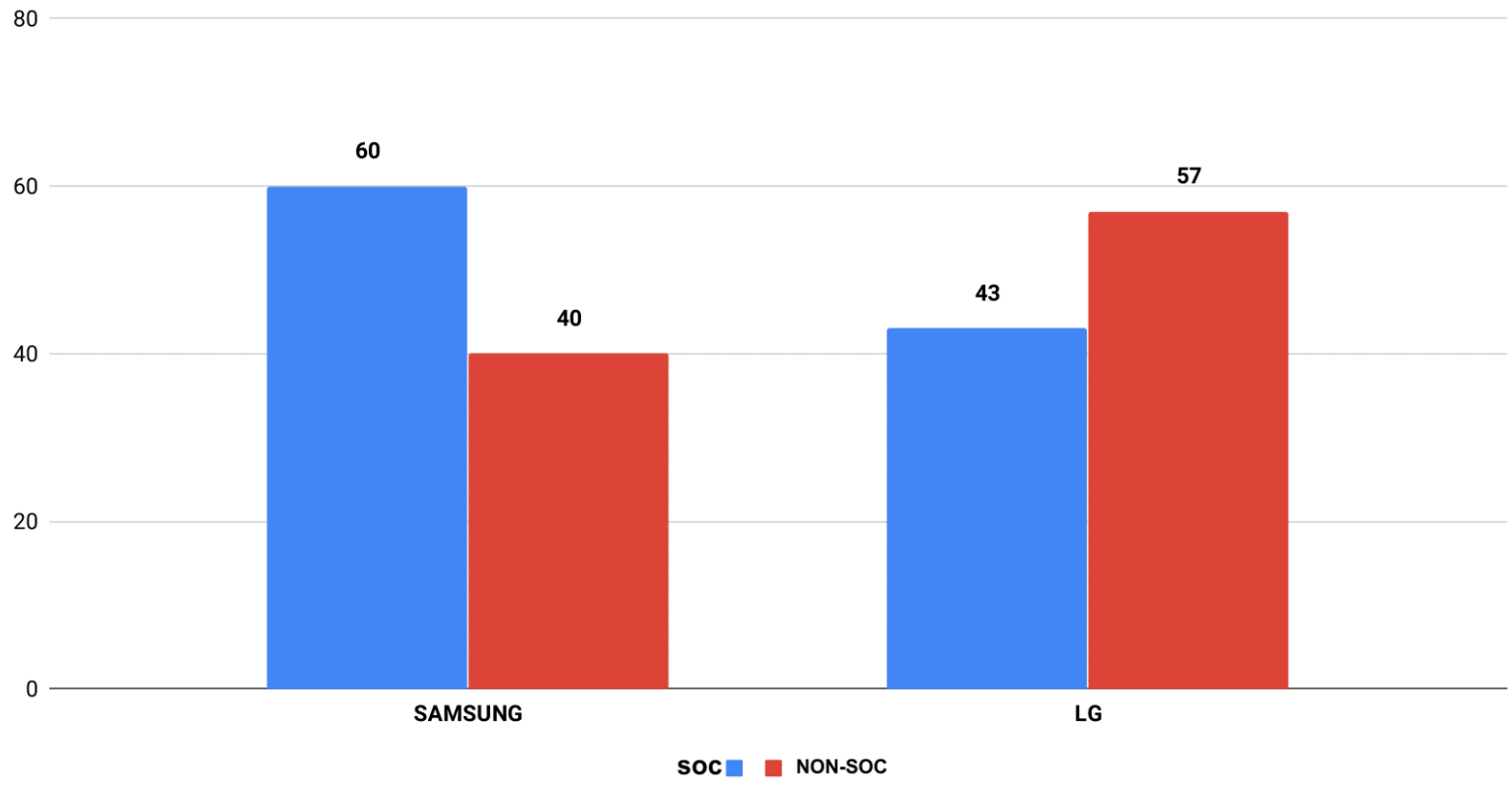
DIGITAL SIGNAGE DISPLAY GLOBAL SALES 2017

Source: FUTURESOURCE CONSULTING Excludes videowalls and interactive displays

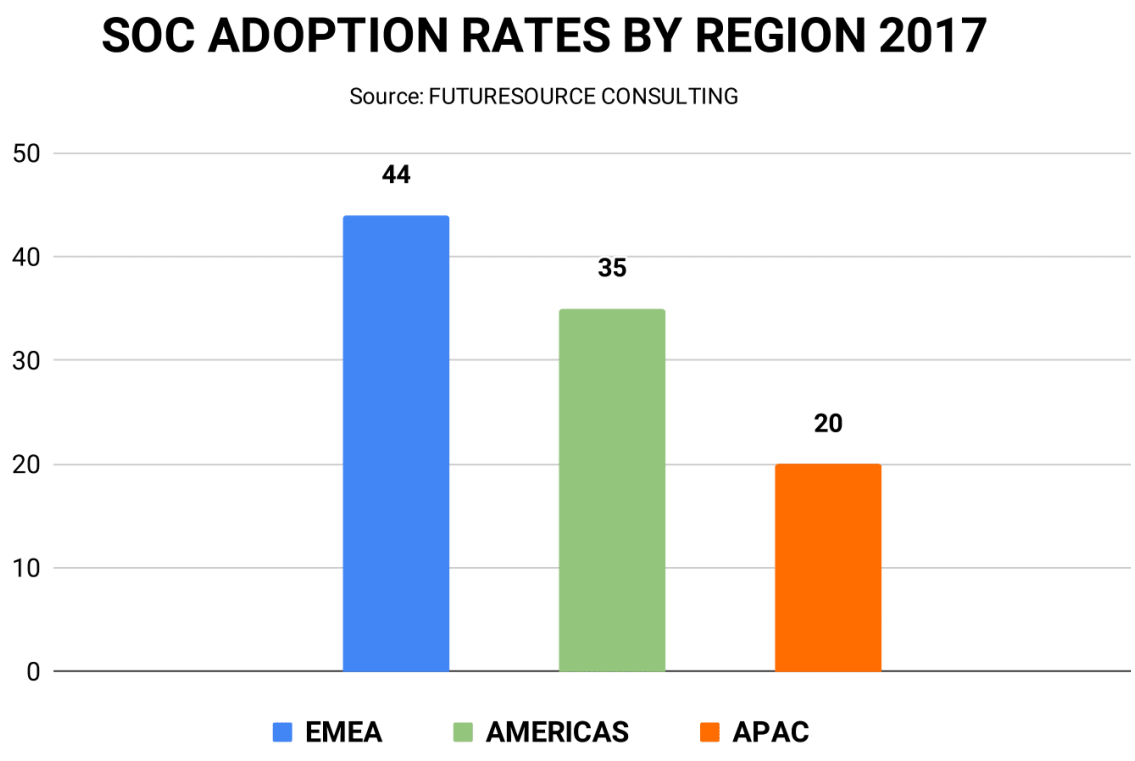


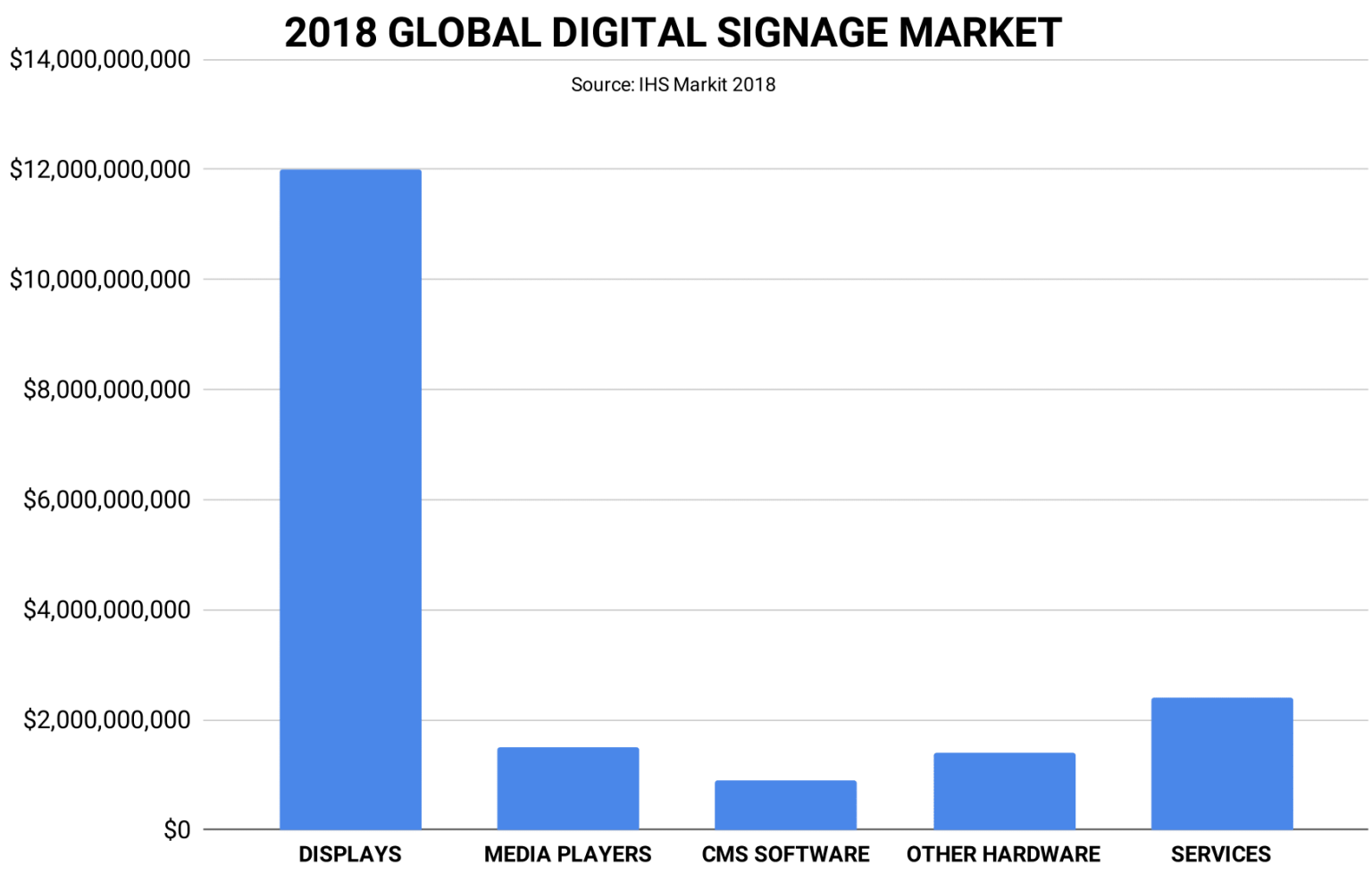
SOC AS PERCENTAGE OF DISPLAYS SALES 2017

Source: FUTURESOURCE CONSULTING



SOC BY THE NUMBERS





BUSINESS ARGUMENTS

The business argument for smart displays has always come down to two things – cost reduction and ease of installation, which also has reduced cost implications.

A typical digital signage configuration involves a display, with content provided by an Internet-connected PC or media playback device. The content is sent to the screen by some sort of signal cable. A smart display, by comparison, has the media player embedded inside the display, as well as the connectivity.

That means a separate media playback device – costing anywhere from $60 on the low end to $700 at the higher end – is no longer needed. The signal, management and power cables for the player are also unneeded. And the mounting hardware doesn't need the additional metalwork of a secure cradle for the player.

So a "smart" display can, in theory, remove a lot of cost from capital budgets, and enable tidier installations that might need just a single power cable for the display.

"If you are a systems integrator and you are going to deploy 500 media players," explains Navori's Moeri, "using System on Chip, you may save up to $300,000 US dollars, which is quite important."

Samsung commissioned a third-party study after it launched its Smart Signage SoC series. "It showed a 30%-35% reduction in Total Cost of Ownership," says Kevin Schroll, Director, Digital Signage Product Group at Samsung. "Only part of that was directly related to the cost of the player, and with that, we weren't assuming a $500-$700 player. The study was assuming it was a $200-$300 player."

There are additional costs associated by embedding and integrating an SoC in displays, but for mass manufacturers who move product by the container shipload, the SoC hardware likely amounts to an extra $15-$30 extra that's usually buried in the overall panel cost.

The total cost reduction, the study found, was roughly half due to reduced player costs, but the balance owed to less cabling and mounting hardware, and lower installation labor costs, because of the reduced complexity of putting screens in.

LOWERING OPERATING COSTS

The total cost argument has also been used as a case against all-in-one SoC displays – with opposition framed around the risks, lost opportunity costs and added labor that would be required in the event of the processor failing.

When a digital signage PC or media player fails in the field, field service and replacement is quick and easy. One small player box can be easily swapped for a pre-configured, pre-loaded spare in a matter of a few minutes. But when a smart display fails, the whole unit has to be de-installed, packed up and shipped to a depot for repair or replacement.

It's a valid theoretical concern, but the experience over more than five years suggests the reliability on the solid state SoC units has been high, and field outages a non-issue. Numerous software companies were asked about their experience with reliability, and none indicated problems.

"That's generally not the area where something fails is the processor," says LG's James Pfenning, National Account Manager, Digital Signage. "If we have a failure of a display it's a power supply or LED related - the back-lighting or something. It's a valid concern, but I think once people understand the stability of the actual chip, it kind of goes away."

Samsung says its failure rate for SoC displays is just 0.3%.

PingHD works primarily in sports, entertainment and quick service restaurants, and uses a lot of smart displays in tandem with its management software. "We are seeing 35-40% reduction in total solution costs," says CEO Kevin Goldsmith, "which in a simple equation means those customers that are actively seeking ROI on their digital signage networks will realize that return quicker if they are spending less."

"Furthermore," says Goldsmith, "we've seen around a 90% reduction in support issues when deploying LG webOS and Samsung SSP displays."

FRIEND OR ENEMY? OR FRENEMY?

Stratacache CEO Chris Riegel is the most prominent hold-out on SoC adoption. He steadfastly says he's not going there, at least not with the Korean companies who are doing most of the trade in smart displays.

"We don't do SOC for Scala, ActiVia, RDM or X2O, nor will we ever," says Riegel. "We don't do Samsung, LG or NEC embedded."

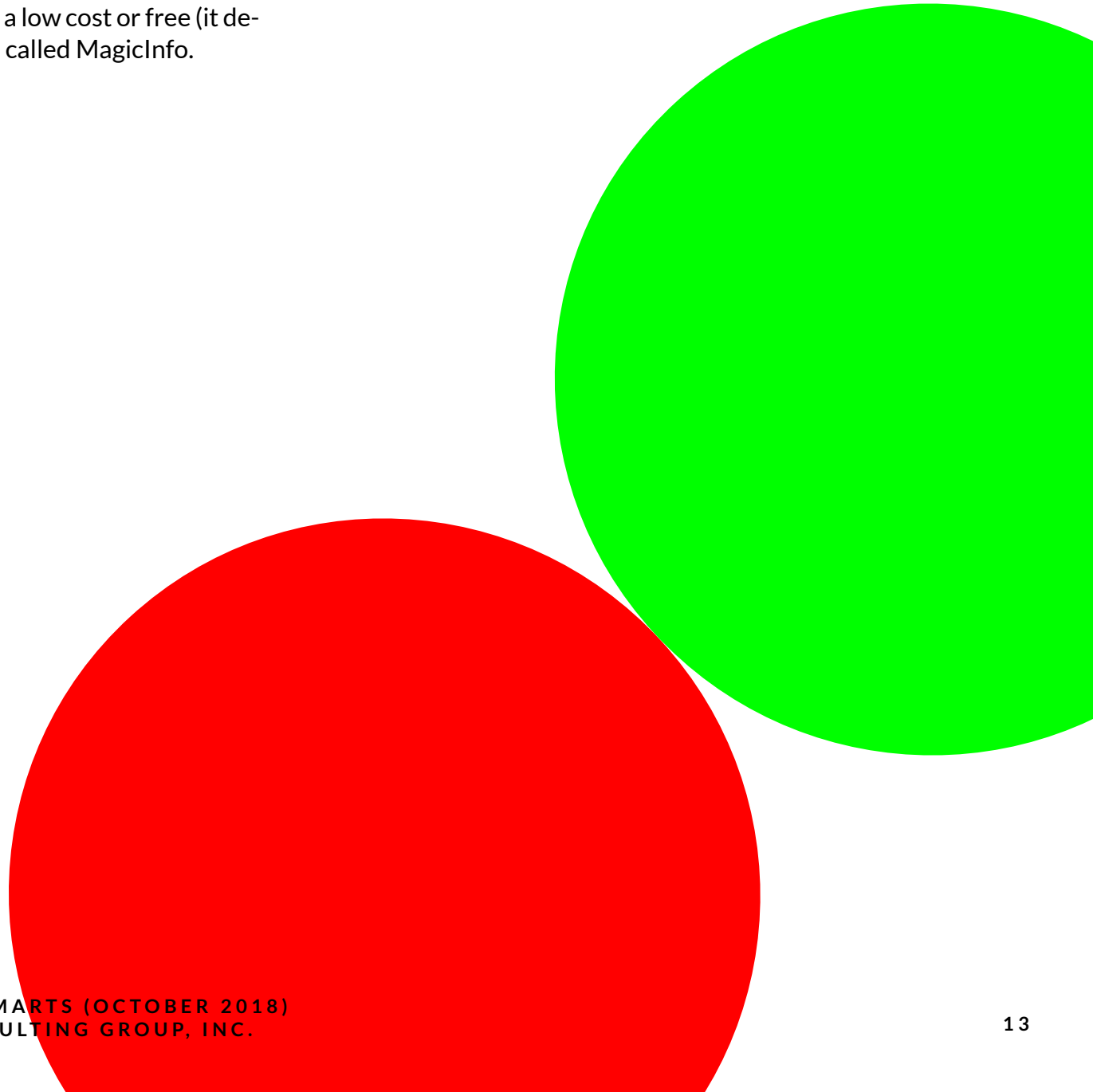
Riegel notes a long-simmering issue with Samsung, and to a lesser extent with LG, regarding its activity in the marketplace. "They directly make their own SoC software and actively promote it globally, and are also now selling NOC, ops, creative and field services. Most of my upstanding North American competitors don't do their homework. SOC is the trojan horse for Samsung and LG to sell their software and services."

Samsung, in particular, has repeatedly raised eyebrows and triggered questions as it has built an ecosystem of software partners for its smart signage platform, while at the same time continuing to develop, evolve and actively market a low cost or free (it depends) CMS software product called MagicInfo.

LG has, meanwhile, for many years marketed its own CMS software product called SuperSign, which has distinct management and control modules, as well as an API programming interface aimed at allowing systems integrators to work with it, and around CMS software companies.

The suspicions extend beyond the Korean display giants. "There are concerns from some people that big panel vendors are learning the CMS and player technology from partners, and will use it to develop their own MagicInfo and SuperSign products," says an executive with a European software firm. "In some regions, those own-label software options are pushed harder than others."

The rationale behind using smart displays has also been openly questioned because of how such systems can, at least theoretically, lock software providers and their customers into certain solutions. Historically, the choice of monitors hinged only on price, performance and support. Operating system was never a factor.



WORKING WITH SOC

The first generations of smart displays came from Samsung and LG, and in both cases, required a substantial investment by software companies in time and developer resources to integrate their Content Management Systems with the devices. Both Samsung and LG required software developers to learn and work with proprietary systems.

For CMS software companies that use web browser technologies as their playout engine, making a smart display work with their software could be relatively easy, as elemental as scheduling a URL and running their signage application like a web server.

But for software companies wanting to fully use their CMS and player capabilities and have a "native" player (not just the browser), much more development time was required.

What the early adopter companies wanted, along with those who steered clear, was a more (or fully) open set-up that allowed them to "port" development they'd already done for Android media player boxes, and then just "tweak" that code for the SoC versions.

There were issues with the lack of good developer information, and with versions of the manufacturer's base SoC code that broke the CMS companies' own software tuned to the displays. That was an issue already familiar to companies that tried to stay on top of the rapidly rolling software versions of Android.

There were also issues with the stability of the early SoC platforms. Displays running their players would, for example, suddenly shut down and reboot, without notice or reason. There were noticeable time gaps between back-to-back videos.

Since then, the companies entering the smart display market have tended to offer "open" Android SoCs that provide friendly, familiar development – and this has been helped by the maturation of Android and, particularly, its web, video and graphics capabilities.

Five years on, CMS software companies say support is better, and there is more open dialogue between the manufacturers and software companies. But not everything is rosy.

SOME OF THE MAIN ISSUES:

- **Software and firmware releases** from manufacturers that break the player software written by CMS companies, as well as moves to new versions that are not backward-compatible. Early adopters of Samsung's Smart Signage program have screens that don't work with the new versions (though at 4-5 years, those screens would be "aging out").
- **Interoperability and standards** – The various display manufacturers all tend to have either entirely different and unique operating systems or if they are using Android, work off different versions. That makes running blended networks that use different manufacturers difficult, though not impossible. One of the value propositions of report co-author signageOS is its ability to act as middleware between the CMS software and various smart displays. Also, different platforms offer differing features.
- **Collaboration** – Both of the major Korean companies now have active user groups and structured meet-up and education events now, to share roadmap plans, hear issues and needs, and foster collaboration. That represents a big improvement over the early days, when changes came out of Korea with little notice or discussion. Of the two, industry observers tend to say LG does a better job of listening to and informing its software partners.
- **Enterprise networks and firewalls** – Smart signage platforms are cloud-based, and larger companies with tight security policies (notably financial institutions) are reticent to use SoC displays. Very localized environments, that have IT teams applying lot of restrictions on a network, are not good fits.

Software companies have found a few paths to making life with SoC easier for them. The first – the most capital and resource-intensive – is writing a native player, instead of relying on browser-based media players that were developed for another medium, and have their quirks.

While many companies continue to rely on browser or what are often called web players that can work across different SoC (and other) platforms and operating systems, companies like Navori have opted instead to develop native players that provide tighter controls and leave them less at the mercy of the display manufacturers and browser developers like Google.

WHEN SOC DOESN'T FIT

Capabilities have both broadened and improved since the early iterations of "smart" displays from different manufacturers, and they are being used for a wide variety of applications.

Current generations from the mainstream manufacturers can easily handle applications such as digital menuboards and digital posters.

"The underlying performance is still low, and limits where SoC can realistically be recommended," says an executive with a well-established digital signage solutions provider. "The gap between our very capable, mature media player and our relatively new SoC player causes confusion. People sometimes incorrectly assume they are like-for-like. As there is so much functionality in the more mature media player platform, accurately documenting the differences is very difficult."

Heavy graphics are an issue, says Omnivex's Bannister. "We have crashed SoC screens by pushing them too hard," he says. "Anything that requires a serious amount of storage space at the player end for content caching or other purposes."

ANDROID'S LOVE/HATE RELATIONSHIP

Talk to some software companies, and they will clearly say they prefer working with display manufacturers who use SoC players and systems that run Google's Android operating system. They like its open source characteristics and access to a vast developer community.

Talk to others and they will say they hate working with Android because it is a moving target, and subject to no end of customization. What Sharp does with Android may be dramatically different from Android, for example, running on Philips' smart displays.

While Android 4.4 is regarded as a milestone – when the operating system's video playback and other capabilities finally aligned with digital signage needs – it is no longer supported by Google.

For example, Sharp's smart display series, released earlier this year, is based on Android 4.4.

Meanwhile, Android development is at version 9 now.

"Android is far more difficult as it is inherently fragmented, you cannot simply consider all Android platforms to be the same, as they have all been customized differently," adds a CMS software sales executive. "Those vendors using Android are outside of the Big 3 (for displays). The ROI does not currently justify the investment in delivering a solution for their platforms."

Android's response to the issue of updates was to introduce Project Treble with Android 8.0 Oreo. The main goal of Project Treble is to make updating easier, and enable faster roll-outs on devices.

How long this change will take to affect digital signage displays is a different question. Google is not simply taking over updates, but optimizing the OS structure for OEMs. It is still in the hands of manufacturers using Android to adopt the Treble standards.

CONFLICTING SOFTWARE OPTIONS

A software company considering SoC displays as a platform of choice is confronted by at least three different development paths – LG webOS, Samsung Tizen or Android. And with Android, different versions of that operating system may support different capabilities.

The platforms offered by both LG and Samsung are somewhat proprietary and have their roots in other systems. The webOS software started years ago as Palm's mobile operating system, and is now the core for LG's global smart TV platform. Tizen is Samsung's own open-source OS intended to work across multiple devices, from TVs to wearables.

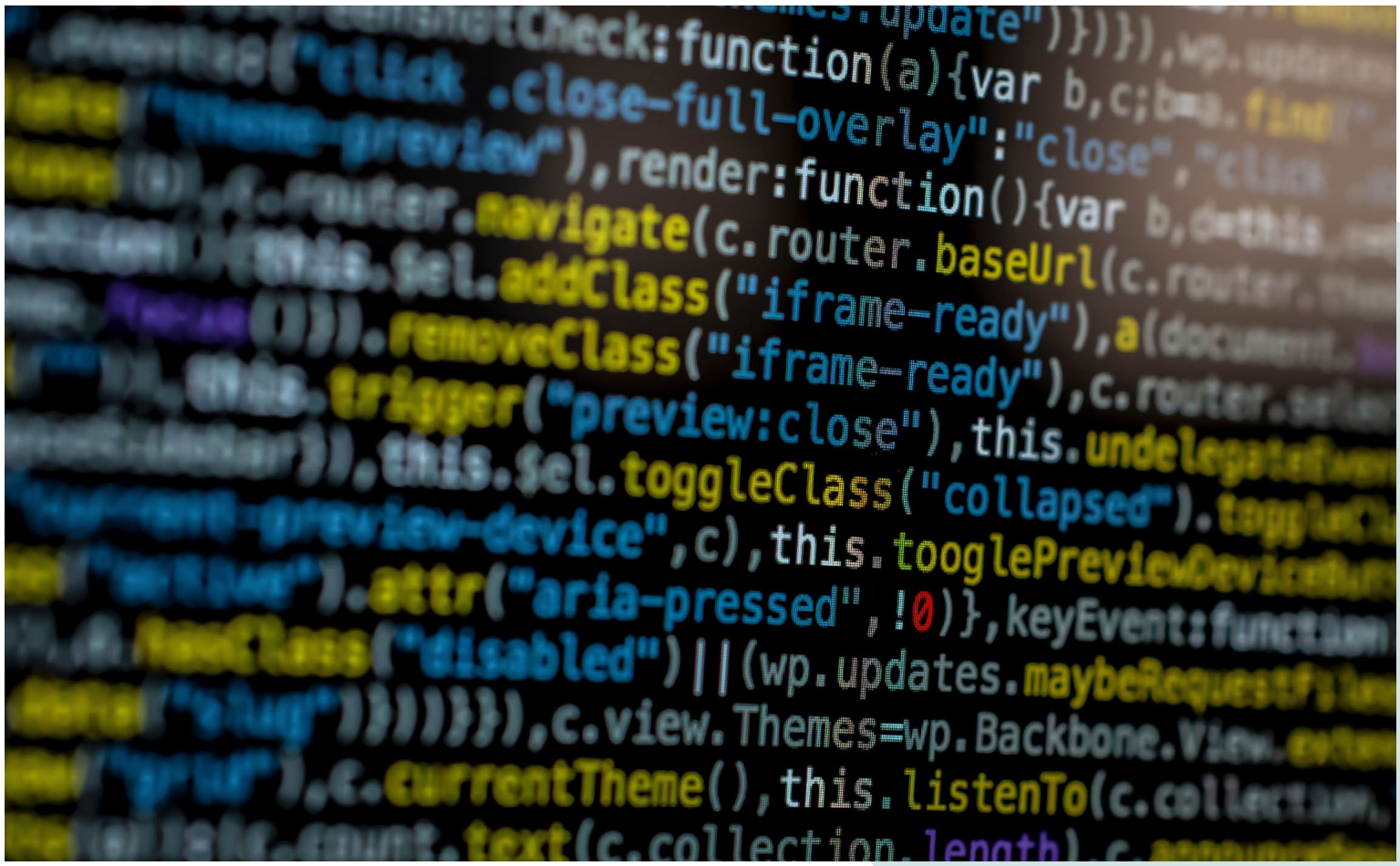
Developing to these platforms means learning the new system, particularly as it relates to the controls and management of the displays. There's a learning curve, and weeks or possibly months of developer resource investment needed to go live on these platforms.

"About 80% of what a provider needs to do is common between a number of different operating systems, so there are a lot of standards that can be used," says LG's Pfenning. "We're only talking about 20%, give or take, that is proprietary to webOS, in that it's the commands and the controls to relate to LG's hardware as much as it is webOS."

"There are, I guess, nuances," adds Samsung's Chan, "because when you take a look and you develop strictly a native app, it is different than developing for the SSSP. And this is one of the nuances. SSSP is built on JavaScript and HTML5 languages. That's pretty open source, for the most part. And what we allow developers to do is utilize specialized APIs to tap into the hardware-specific commands and controls - such as on or off, picture in picture commands, even remote diagnostics or going right into the file system. So those are all computing level APIs that could easily be, I would say, achieved."

Companies such as Panasonic, Sharp and Philips do not have proprietary operating systems, and instead market smart displays that run on Android and offer a system that is open and friendly to software companies that already have experience developing solutions for Android-based media players.

Developing for Android provides a very large reference base and support community but getting lost in the sea of Android versions and updates can feel daunting.



CURRENT SOC PERFORMANCE OVERVIEW

The SoC performance overviews are derived from three performance tests run by signageOS to answer two questions:

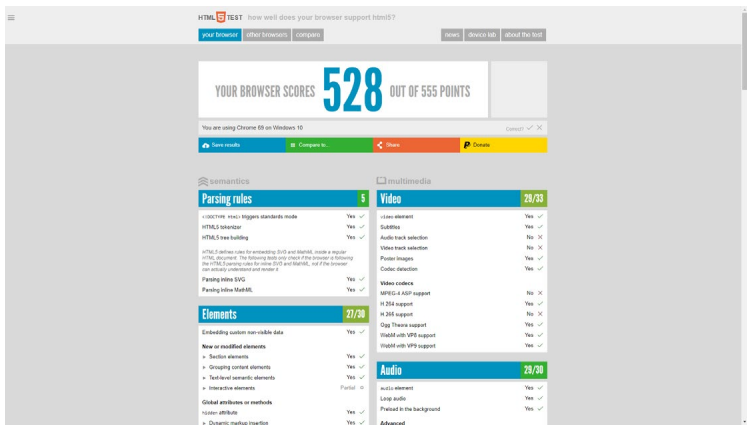
1. Can the SoC display run modern, rich HTML5 applications that have become standards for digital signage?
2. If they can, how well?

THE THREE TESTS:

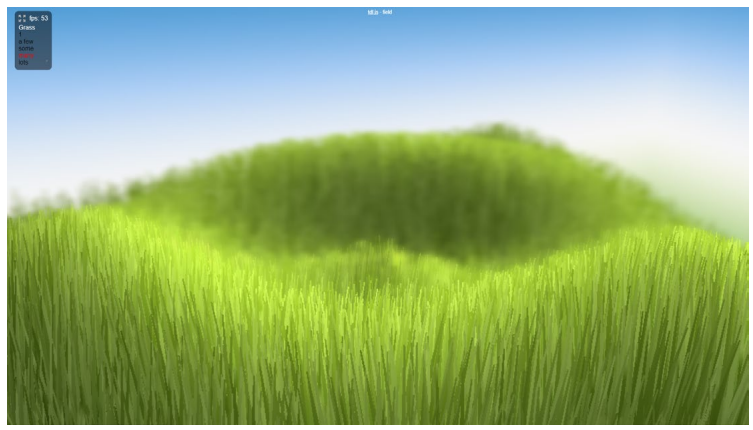
1. **HTML5 support test**
2. **WebGL test**
3. **JS DOM test**

These tests provide an accurate account of performance on some of the most popular SoC platforms. The displays used for testing included some of the largest manufacturers of SoC displays, as well as companies with newer SoC product offerings.

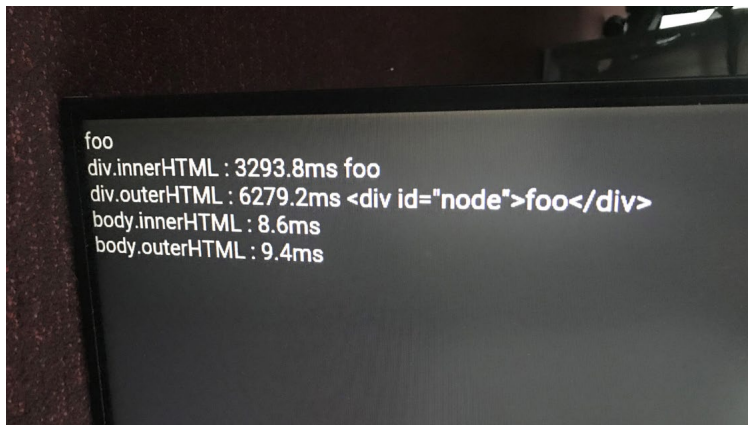
HTML5 SUPPORT TEST



WEBGL TEST



JS DOM TEST

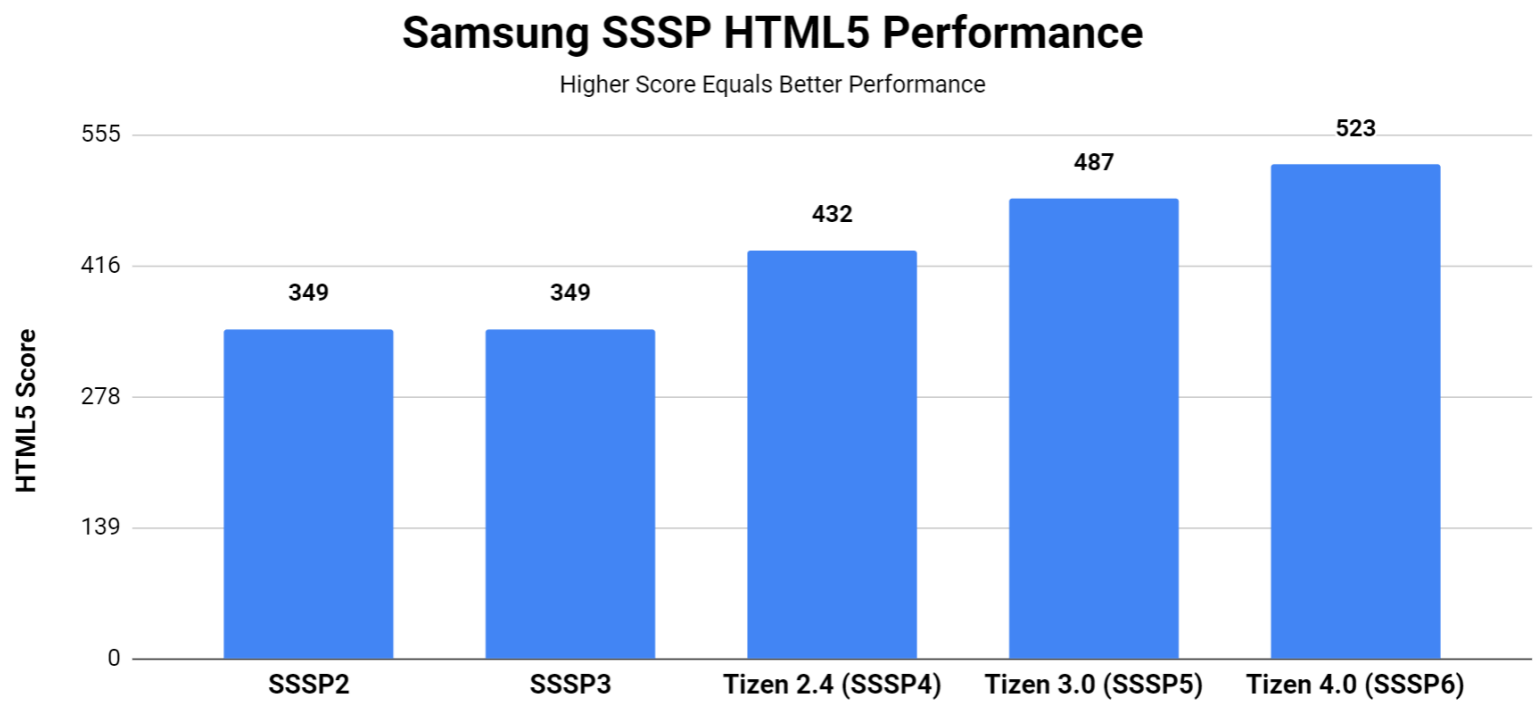


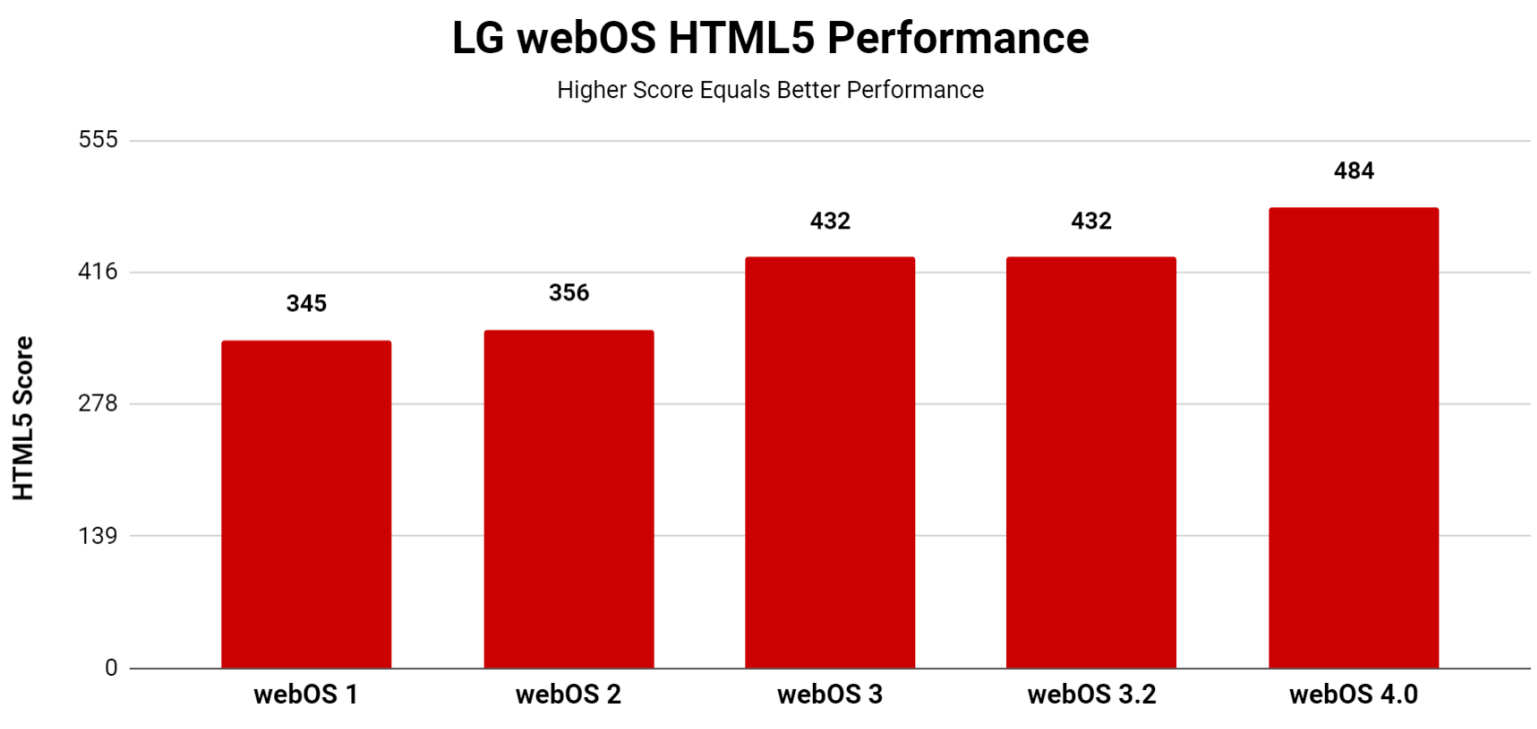
1. HTML5 SUPPORT LEVELS

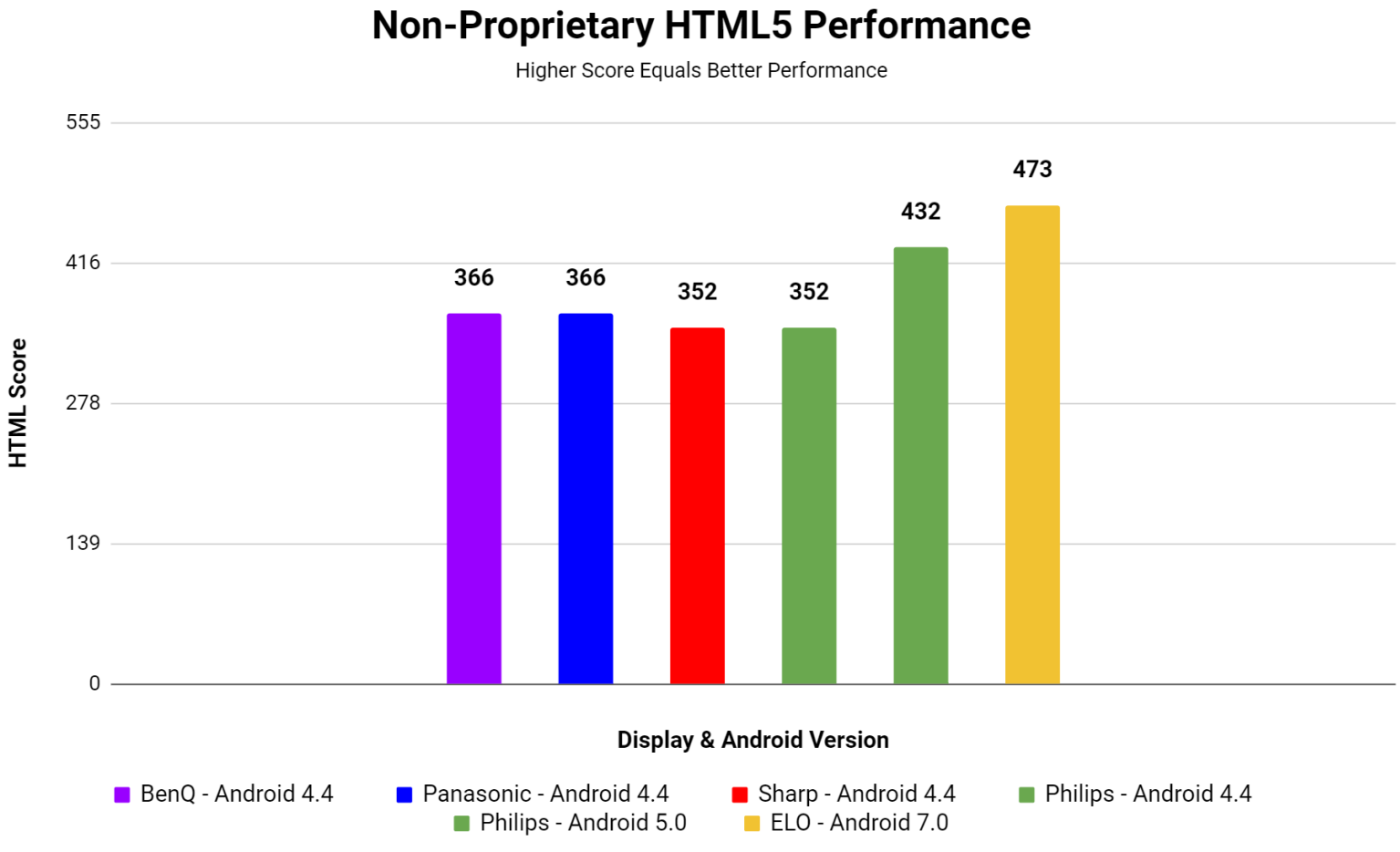
The HTML5 performance test examines features that are defined in the W3C HTML5 specification and other different features that have been added to browsers in the past few years. Applications running on smart displays are HTML5 based.

This test takes the characteristics of HTML5 applications and tests their strength on different displays. Examples of tested metrics include: parsing rules, elements, web components, streaming, responsive images, output, input, web applications, and many more.

Although the highest current score possible is 555, achieving the maximum score is highly improbable. The newest version of Chrome (v. 69) scored 528.







The performance benchmarks were tested on displays by different manufacturers running on each version of operating system or proprietary software. Testing multiple displays on each version of the software provides a more accurate representation of performance over time.

The results of the HTML5 performance benchmark, as one would expect, indicate that with each newer version, performance increases drastically, year over year.

As a counter-argument to SoC displays not having the computational power for certain digital signage projects, these figures represent the growth of power behind SoC over time.

The results for non-proprietary performance benchmarks are more difficult to interpret because the majority of the tested displays are running on multiple versions of Android, regardless of their release date.

The key takeaway from the HTML5 performance benchmarks is that the growth in performance with proprietary displays is consistent over time, while non-proprietary scores are spread across the board due to displays operating on different versions, regardless of their release date.

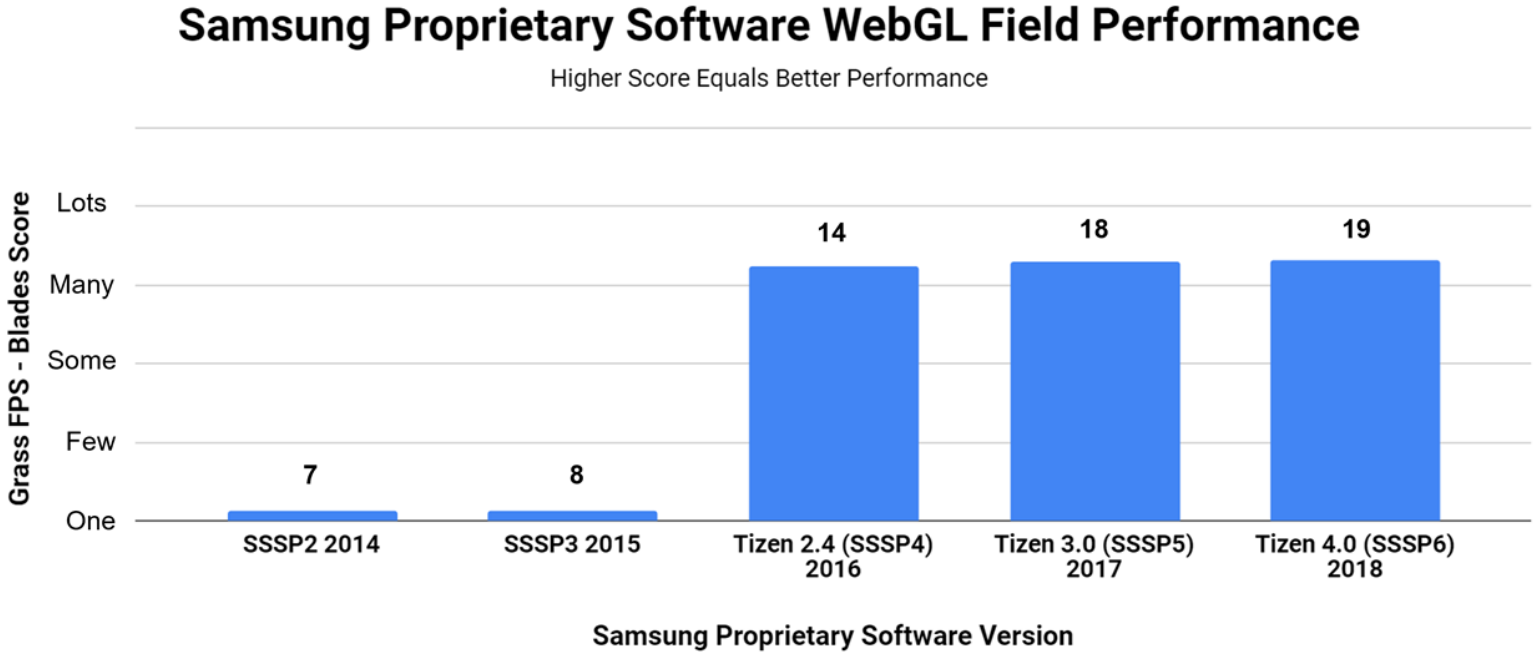
2. WEBGL PERFORMANCE LEVELS

Google developed WebGL performance test as a Javascript API for rendering interactive 2D and 3D graphics with any compatible web browser, without the use of plugins. The WebGL test examines the GPU power of the displays. Multiple samples of WebGL performance tests can be used, including Aquarium, Fields, Dynamic Cubemap, and many other popular options. Regardless of the test type, the information gathered from the test is the same.

The results of the WebGL tests explain how many frames per second a display's SoC can efficiently produce. The y-axis represents the number of patches of moving grass the display is able to produce (from One to Lots), with levels having more patches.

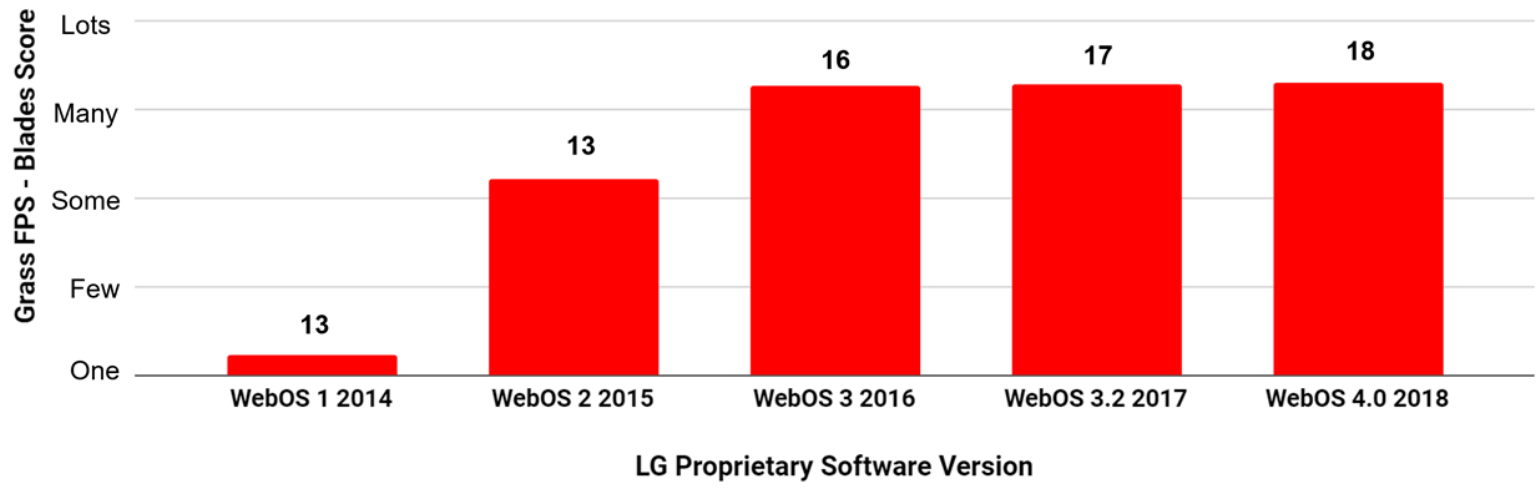
The number on top of each column represents the number of frames per second with however many patches (between 0 – 60FPS). For example, a display that can show "One" patch of moving grass at 40 frames per second is far lower performing than a display that can produce "Many" of patches at 40 frames per second.

For reference, new version of Chrome (v. 69) on Windows 10 machine powered by Intel Core i5 scores between "Many" at 60FPS to "Lots" at 50FPS.



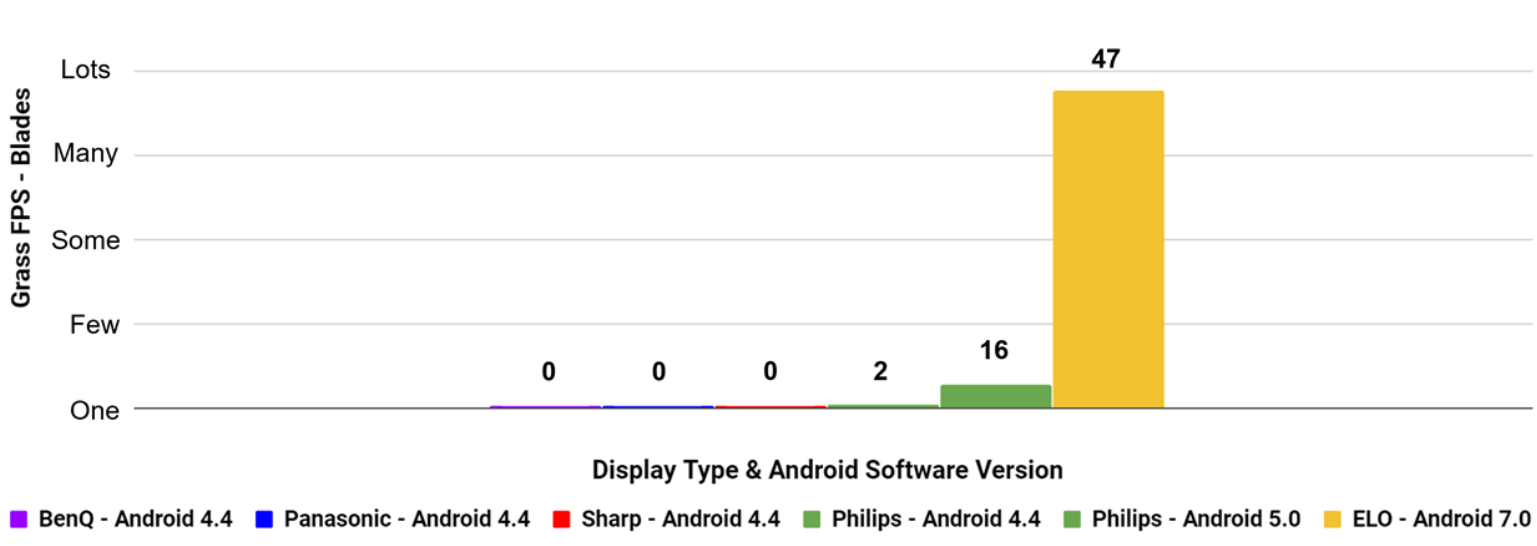
LG Proprietary Software WebGL Field Performance

Higher Score Equals Better Performance



Non-Proprietary WebGL Field Performance Benchmark

Higher Score Equals Better Performance



The results of the WebGL performance tests differ from the HTML5 test for proprietary software in that with the newest version of software the scores level off with the previous years.

Again, proprietary solutions had a consistent increase in performance over time until the newest version.

Non-proprietary software did not fare so well with this performance benchmark, as their graphics processing could only display One patch of grass at a very low FPS. Displays running on newer versions of Android, like ELO on Android version 7.0, completed the WebGL test with outstanding scores, proving the increase in graphics processing capabilities in the newer Android version.

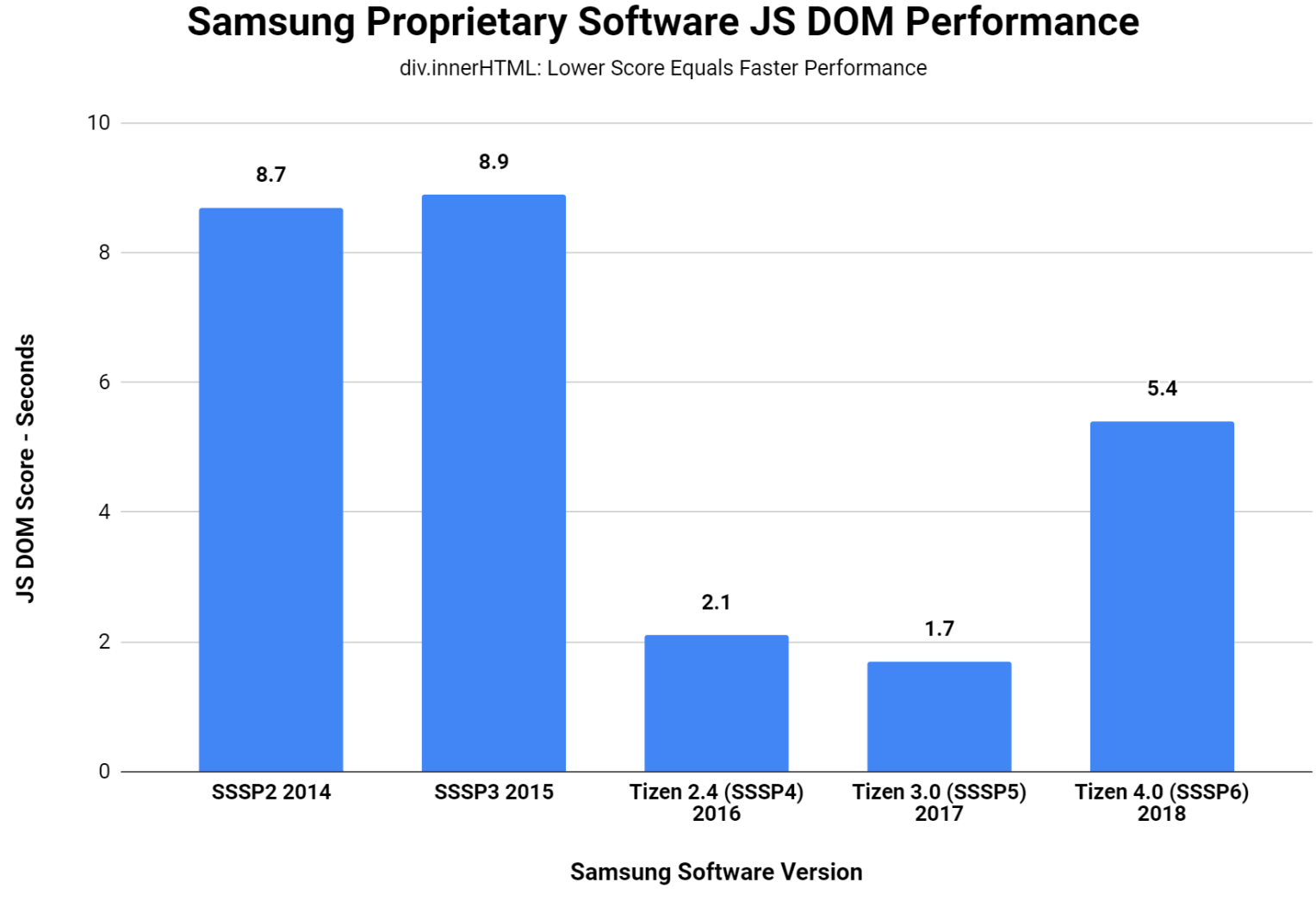
3. JS DOM MANIPULATION PERFORMANCE LEVELS

The Google and WebKit developed Javascript DOM (Document Object Model) code tests the time of property accesses and node repositioning within HTML5 page/app. The test measures the time it takes for the DOM to recall elements on a display while using a sample code snippet that contains one million elements.

Normal DOMs will not have one million elements, so this is a way to benchmark performance while using a consistent independent variable. So, the higher JS DOM score, the longer it takes for the display to process HTML5 elements of the DOM and the slower the device is.

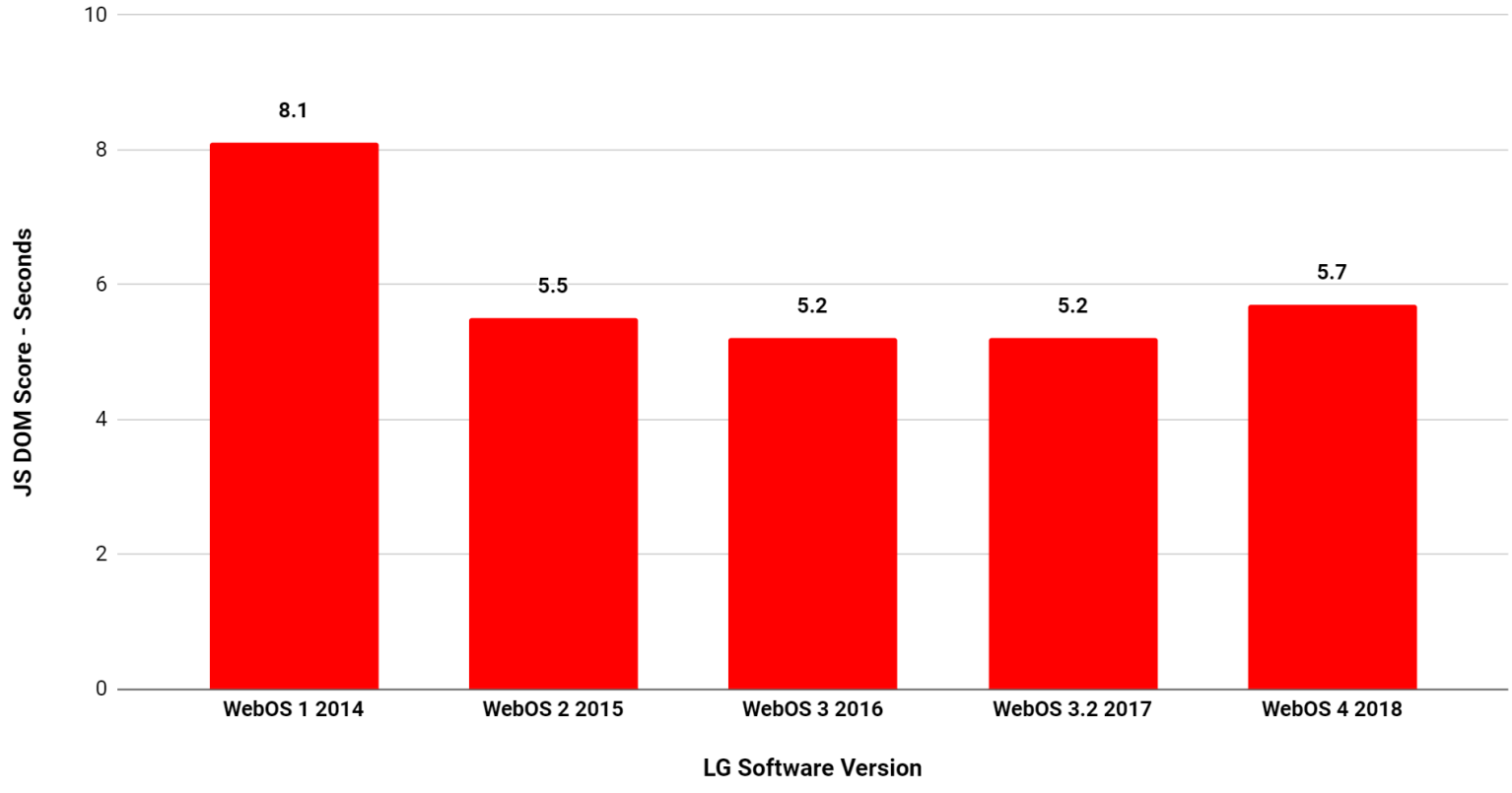
The objective of the JS DOM performance test is to view how fast displays can recall elements of HTML5 content on a display. This test shows how fast a display can manipulate and change the html content of the page.

Reference results for Windows 10 Core i5 machine is 0.6s.



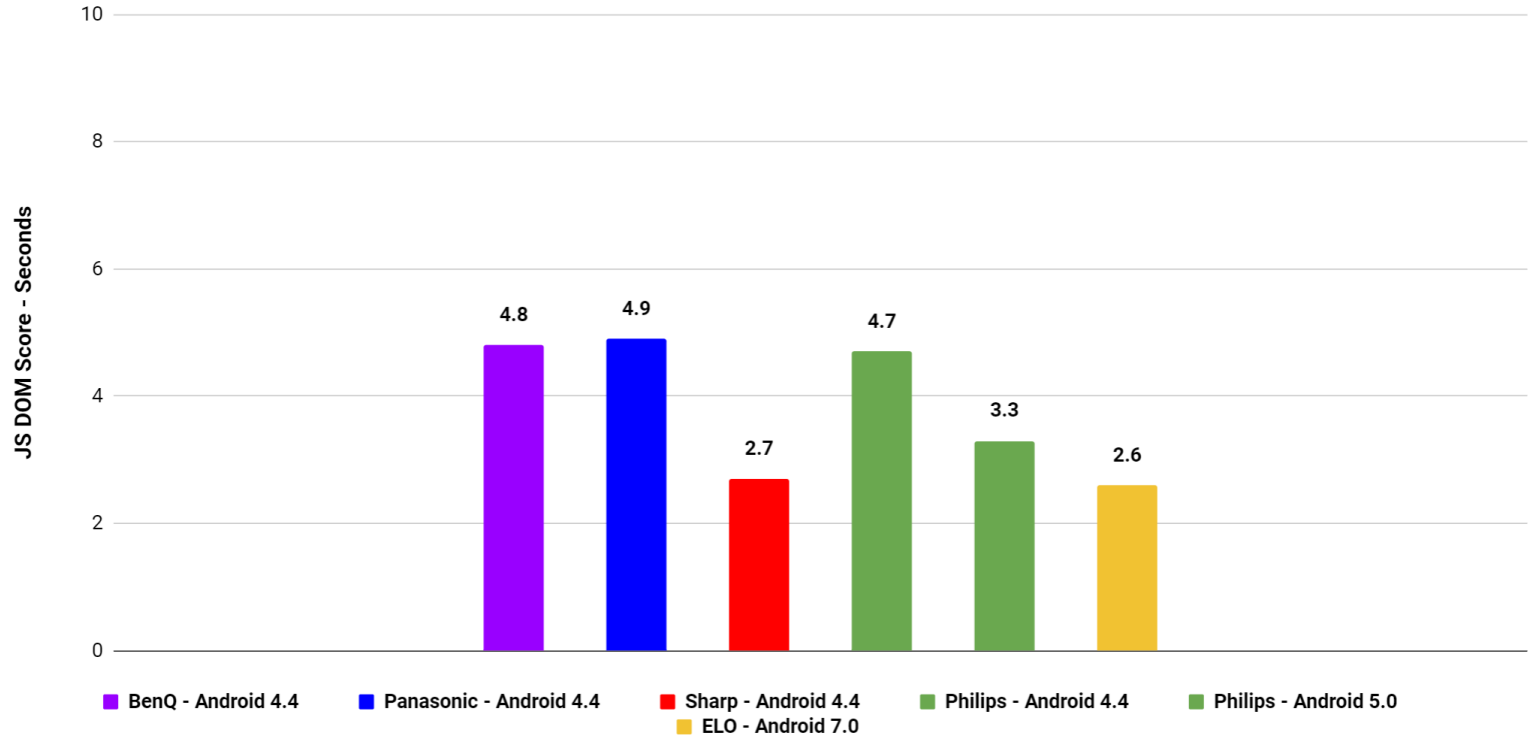
LG Proprietary Software JS DOM Performance

div.innerHTML: Lower Score Equals Faster Performance



Non-Proprietary Software JS DOM Performance

div.innerHTML: Lower Score Equals Faster Performance



The results of the JS DOM are similar in that they improve over time. However, the newer platforms are still being affected by earlier firmware versions and new web engine.

The newer web engine currently in use is more performance-demanding but also brings more features, which reflects the higher score in the HTML5 test. Newer firmware releases will improve their results over time.

Also, with newer versions of Android, scores have drastically decreased except for one, which is Sharp on Android version 4.4. The fact that not many displays operate on the newer versions of Android leaves one to believe performance, as well as security, will greatly increase as more displays adopt the newest versions of Android.

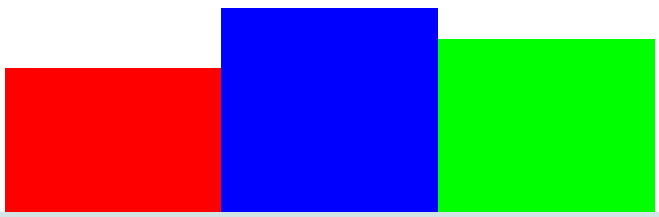
TEST CONCLUSIONS

It is common knowledge that performance with earlier SoC displays was not great. But SoC displays have progressed a great deal in performance since their initial introduction. The results indicate that performance over time should continue to increase, suggesting that SoC displays have still not reached their full potential. Computational capabilities of current SoCs are just now meeting the majority of modern digital signage requirements.

It is absolutely fair to state that with these recorded scores, combined with well-crafted CMS software, SoC displays are capable of delivering seamless experiences for most of today's digital signage installations.

DISCLAIMER

For standardization purposes Android-based platforms performance was tested solely to reflect the ability to run HTML5 content. The performance of the native Android applications might differ thus cannot be objectively compared. For the Proprietary platforms the scores may differ based on the firmware version used.



ARE SMART DISPLAYS SECURE

Software company CTOs career paths are guided, at least in part, by their ability to navigate their companies through the security minefield of the Internet, and relatively new devices that take the place of more-familiar PCs understandably cause some heartburn.

Since the inception of SoC, there's been an ongoing debate about the security, vulnerabilities and data integrity of smart displays. The CEO of one of the more dominant solutions providers in the digital signage business has steered clear of SoC, saying he does not trust the manufacturers, and suggesting at least one display company has security back-doors that send data from displays back to the manufacturer.

Since 2013, there have been recurring areas of discussion and concern expressed by manufacturers, CMS companies, and integrators/solutions providers. They break down like this:

- ➜ current state of security
- ➜ comparing competing technologies
- ➜ progression of versions and updates
- ➜ legal ramifications
- ➜ future-proofing

The companies who contributed to this report generally say SoC displays can be as safe, or even safer, than conventional PCs that are running Windows or Linux. But that level of security depends on the efforts made by the manufacturer.

"It varies by manufacturer. Some are very good. Some aren't," says Omnivex CTO Doug Bannister, whose company has long focused on Windows, but has recently started to adopt SoC to meet customer requests. "You need to consider all aspects of the device, however, and not just the OS. For example, can I walk up to a screen with an HDMI thumb drive, plug it in, switch the input over and take over the screen? Can I shut off the screen with a standard IR remote? Sure, most screens are not accessible this way, but a lot are. Can the screen and OS be configured to prevent this?"

"SoC can be as safe, if not safer, than an x86 player depending on the operating system, configurations, life cycle, and update strategy," says Viktor Petersson, CEO of the UK CMS software firm Screenly. "Regardless if it is SoC or x86, if the devices are not properly updated, they run a fair chance of being compromised."

A proprietary operating system, with digital signage largely in mind, is almost certainly going to present fewer risks than an operating system like Android, built to work across a broad spectrum of consumer devices, and used in everything from slight to wildly different ways by different manufacturers. Two set top boxes that look very much the same, and do the same things, may have substantially different versions of Android running on them.

Samsung and LG are, by a broad margin, the most active display manufacturers in smart signs. Samsung's Tizen-based Smart Signage display series integrates its Knox mobile security platform, which has US NSA approval and provides a multi-layered solution protecting systems against external attacks. It also has security APIs to Tizen developers.

LG's WebOS 3.5, released last year, has Common Criteria (CC) Certification, internationally-recognized standards for security that covers application installation protection, application execution protection, and application content protection with digital rights management (DRM) encryption.

Newer versions of Android have been developed to provide better security, among many other positive changes. But displays are not updating their Android versions to keep up with the current, safest version.

This results in more vulnerable installations, given that Android's developers have surpassed those levels of security and updates. This points to the lack of updates being the responsibility of the vendor or manufacturer. Considering this differentiating factor when choosing the display type is a must.

Another main issue with security is longevity. Displays are manufactured to withstand a project that lasts for years without the guarantee of security updating for the same amount of time.

A major problem arises when older versions of software remain in use, that then become incompatible with newer forms of security protocols. The displays require numerous patches to thwart security vulnerabilities, or become obsolete. This holds true for proprietary and non-proprietary software.

“There was a bit of hesitation from manufacturers when requesting patches and updates for the very old SoC displays. In the end, the patches were always delivered and we hope manufacturers will continue to deliver them, in order to address issues even with the older SoC versions – not only the current display lines,” explains Lukas Danek, Head of Product, signageOS.

The state of security in digital signage is at a major crossroads, as we see more and more failures and hacks. What is known is that companies are recognizing the need for improved security practices with digital signage, and taking positive steps.

CONCLUSIONS

SoC is a thing now. A big thing. Right or wrong, it has been mainstreamed.

All of the display guys are doing some version of it, and the great majority of the software companies. One driver behind that: five years ago companies had to explain to customers what smart displays are all about, but now the customer base is largely educated and proactively raising SoC as an option or even a preference.

The attractions are obvious:

- ➜ Reduced capital costs because the external player and cables, etc, are gone.
- ➜ Faster installs and therefore lowered labor costs.
- ➜ Reduced field servicing – because many points of failure (like loosened cables) are out of the picture.

Based on testing, it's also pretty obvious that these smart displays have come a long way, in terms of capabilities. Digital signage is increasingly driven by web technologies, and the latest generations of smart displays seem to be entirely up to the task. The outliers, it could be argued, are those companies that are running Android as their operating system, but using quite old versions. The test results from Elo's product, which is several generations of Android ahead, strongly suggest that makes a difference.

There are some big business questions to be asked, particularly by software companies, about who they select as smart display partners. In some cases, smart display vendors have competing software products. Developing for a particular smart display system can, also, lock both the vendor and its clients into that solution.

That said, several companies have platforms that cross different operating systems and players, and signageOS – a big part of this report – is specifically in the business of creating a software bridge that allows companies to work with multiple display vendors.

As with just about anything in digital signage, it's not absolutely clear where the technology and industry will go. But the naysayers who have openly questioned whether anyone was actually using these smart displays are much quieter these days.

Talk to people who sell digital signage PCs for a living and they will confirm these are lean times, as buyers are now educated to the point of knowing what smart displays are, and how they can trim capital budgets.

Software vendors and solutions providers, looking for any edge they can find in a crowded market, are keen to come in with lower project cost quotes. Smart displays help that.

Right or wrong, smart displays are now rolling out in big numbers.

ACKNOWLEDGEMENTS AND NOTES

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