I Want My 4K MTV!

The future of digital video is expanding in all directions; from the size of the living room TV, to the depth of content selection, and to the different types of devices which serve content. A culmination of technologies is brewing that is bringing an IMAX-esque[1] experience to the living room. It is not difficult to imagine that in the next ten years subscribers will be *unraveling* and *gluing* their TV's onto their wall. A culmination of the following innovations will make this happen:

- Televisions are growing to the size of an entire wall. Several 100" television sets (2.5 meter diagonal) have been introduced to the market over the years, and prototypes of even larger screens have also been showcased. As screen sizes continue to increase, the only limiting factor will be the available wall space.
- Displays are verging on the thinness of credit cards, thanks to technology such as OLED[2]. Organic Light-emitting Diode, displays have been recently introduced in 2013 as thin as 4mm[3] by LG[4]. Although OLED had a slow start due to high manufacturing costs and other technical issues, it still offers a promising future for ultra-thin and ultra-high resolution displays. Namely due to the fact that each pixel is self-emissive (i.e. they emit light without requiring a back-lit layer). As screens become thinner, this leads to the inevitable availability of…
- Flexible displays[5]. These have also been announced from manufacturers such as Sony[6], Samsung[7], as well as display technology manufacturer, Corning[8].
- Higher resolutions are now being introduced to the market such as 4K[9] (aka. UHD, Ultra High Definition video). When display technology verges on the size of walls, then even 4K will not satisfy consumers, and 8K, or higher will begin to steal the attention of consumers.
- Computing power to crunch through all that Ultra High resolution data is readily available.
- The ability to deliver hundreds of megabytes in bandwidth[10] to the average consumer is on the horizon.

These advances in home video may seem like a distant dream, but the future is closer than most realize. 4K television was a hot topic at the Consumer Electronics Show, CES '13[11], in Las Vegas this year. But some consumers may feel that 4K has been introduced too soon. Especially considering that Blu-Ray only recently reached strong sales momentum, and HDTV[12] has finally established a firm foothold in the living room - penetrating also the mobile market. So why 4K video, and why now?

> *Despite the absence of accessible 4K content, any new market first requires a chicken or an egg …*
>
> *Introducing 4K monitors in 2013 launches this next evolution in video*

[13]

When viewed from the perspective of technology penetration, this is the perfect time to introduce Ultra HD. Higher resolution displays immediately benefit consumers wanting the most real-estate on their devices. More windows, icons, and widgets can be displayed side-by-side in all their high-resolution glory. Businesses and enthusiasts have already been using display resolutions higher than HD for several years. For example, the popularity of 2650x1600[14] (2.5K displays perhaps?) steadily increased as prices dipped below $1000. More recently, Apple released their retina[15] displays in the latest generation of iPad's (2048x1536 resolution at 264 pixels per inch, ppi) and MacBook Pro laptops, at even higher resolutions (2880x1800 @ 220 ppi). Consumers are quickly becoming acclimated to high pixel densities. Retina displays enhance the subscriber's viewing experience on smartphones, tablets, and laptops, and create a precursor for ultra-high resolution content.

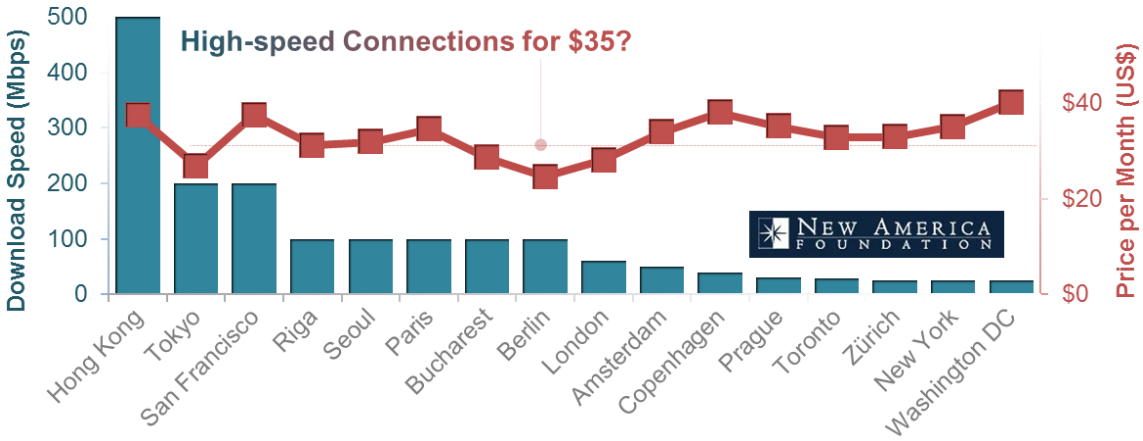


Figure i – Top 16 cities for High-speed connections @35 US$ per month

So how will this Ultra HD content reach the subscriber in the first place? Some cities already offer bandwidth that can accommodate a 4K live video stream[16]. According to New America Foundation[17], at least 12 cities currently offer affordable download speeds above 30Mbps (Figure i). This is well within the bandwidth requirements of a single 4K video live stream[18] (assuming *typical* streaming quality, and that the internet pipe isn't being used for

anything else). Moreover, this is offered at a very reasonable fee of 35 US$ per month[19]. At a national level, Asia Pacific rank in the top three. European countries share six of the top ten positions, and the United States holds steady in ninth place (Table I). Even though the national average of some countries can barely accommodate a real-time high definition stream (typically between 4Mbps to 8Mbps used for online HD streaming), the peak download speeds exceeds 30Mbps are enjoyed in a select number of cities around the world.

Average & Peak
Top 10 Countries

NEW AMERICA FOUNDATION

Country	Region	Avg. #	Average Speed (Mbps)	Peak. #	Peak Speed (Mbps)
S. Korea	Asia Pac.	1	14.7	2	48.8
Japan	Asia Pac.	2	10.5	3	42.2
Hong Kong	Asia Pac.	3	9	1	54.1
Switzerland	Europe	4	8.7	7	32.4
Latvia	Europe	5	8.7	4	37.5
Netherlands	Europe	6	8.5	9	30.7
Czech Rep.	Europe	7	7.6	16	27.3
Denmark	Europe	8	7.2	19	26.5
U.S.A.	N. America	9	7.2	13	29.6
Finland	Europe	10	6.8	25	25
Romania	Europe	16	6.4	5	37.4
Israel	MEA	23	5.6	8	30.9
Singapore	Asia Pac.	27	4.9	10	30.7
	Global Average		2.8		15.9

Table I - Top Countries for Average & Peak Internet Speeds

In any case, sending 4K over today's internet connections will not be optimal using today's encoding standards. Streaming encoders would need to utilize the newly finalized H.265[20] format. Current tests show a 15%-20% improvement on the currently ubiquitous H.264 codec, but as implementations of the codec are optimized, promises of a 50% improvement in compression efficiency is anticipated. This means that a 4K movie streaming with a frame aspect ratios of 2:39:1 (aka. Cinemascope typical for Hollywood movies) could be delivered quite comfortably within an existing 30Mbps internet connection. Alternatively (as shown in Table II[21]), in the case of a Video on Demand (VoD[22]) service, a 4K movie could be downloaded within 1.5 hours over a 30Mbps connection. HD content using the same service would download in just under 20 minutes, and standard definition (SD) content would complete in little over six minutes[23].

This begs the question; Is there a bottleneck today, in delivering 4K video to consumers? In fact, it could be argued that for major cities in the top 25 countries in the world, there no bottleneck[24]. Internet speeds are continually improving, expanding to new cities, and becoming affordable. Further down the pipe, WiFi standards such as 802.11ac[25] promise theoretical bandwidth capabilities from 87Mbps and higher, to comfortably carry several 4K streams (Figure ii) Alternatively, LAN[26] speeds of 100Mbps have been available for over a decade, in consumer electronics. As for the final connection between the set-top-box and the TV, the current iteration of HDMI 1.4 already has the capacity to deliver a 3840×2160p (progressive scan) signal at 24 or 30 frames per second, (or 4096×2160p at 24fps). But it is the development of HDMI 2.0, currently in the works, that will extend support to 60fps. This is important because broadcasters will send 4K content to subscribers at their usual 60 frames per second (fps) used in the USA, or 50fps (used in Europe). Furthermore, HDMI v2.0 will support a Transition-Minimized Differential Signal (TMDS[27]) of 18Gbps which is ample bandwidth for the final delivery of uncompressed 4K video to the television.

Download Time (H.265, 2.39:1, Qf = 0.1)

Video	Frame Size	bitrate (Mbps)	Size (GB)	30 Mbps h:mm:ss	pixels/ frame
SD	1024 x 432	**1.6**	**1.3**	0:06:20	0.4m
½HD	1280 x 528	**2.4**	**2.0**	0:09:41	0.7m
HD	1920 x 800	**5.5**	**4.6**	0:22:00	1.5m
4K	3840 x 1600	**22.0**	**18.4**	1:28:00	6.1m

Table II - File size, & download times by Video type

To be fair, the main bottleneck in delivering 4K video to consumers is likely in the processing power of the devices responsible for encoding and decoding video. H.265 is expected to take as much as ten times longer to encode video, compared to H.264. Furthermore, 4K has four times the real-estate compared to HD. Therefore, curators of video transcoding should anticipate at least a 40x increase in encoding time when comparing *HD@H.264* encoding to *4K@H.265*. Thankfully, decoding of H.265 is only two to three times more costly compared to H.264, but adding 4K. So adding 4K to the frame will require consumer processors to be at least ten times more powerful than they are today. Whether it be a set-top box, gaming console, or media center appliance, these CPUs will need to be; a) powerful enough to decode 4K in combination with H.265; and b) affordable for the price sensitive consumer electronics (CE) market.

An IMAX-esque Experience

While a full back-catalog of digitally restored Blu-Ray content is voraciously being released on a weekly basis, there are looming questions regarding the absence of available 4K content. *Certainly, 4K TV can only be successful if content is available to take advantage of its glorious resolution*. But this leads to the inevitable chicken and egg predicament; Which should come first, a) the infrastructure supply chain all the way down to the display, or b) the

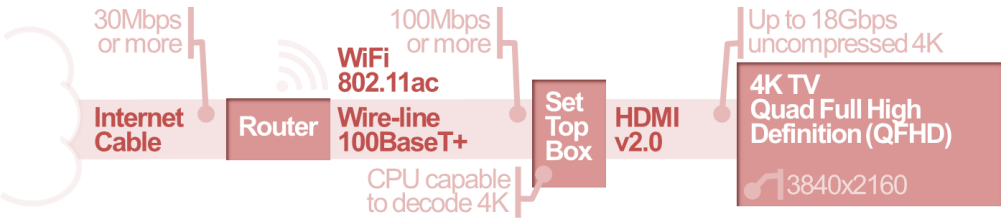


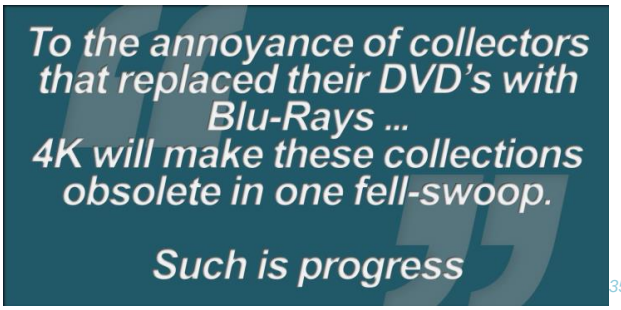
Figure ii – 4K digital video to the Consumer - Minimizing the Bottleneck

content? It certainly makes sense that display technology should precede the release of complementary content, and this has ultimately been the industry approach for introducing 4K.

[28]

Figure iii - Flexible Displays by PowerFilm

To fuel the anticipated transition to UHD, a wave of film restoration over the past decade has resulted in the scanning and digitizing the Hollywood[29] back-catalog. Thanks to digital restoration pioneers such as Lowry Digital[30], now owned by Reliance Big Entertainment, high ticket items such as the *Disney*[31] and the *James Bond*[32] collections were some of the first titles to be digitally restored. At the moment, as many as eighty Blu-Ray titles are being released on a weekly basis[33] - some of which are digitally restored back-catalog titles, and others are recent theatrical releases filmed using 4K digital cameras. It has become standard practice to scan and digitally restore old film masters to 4K, then transcode or downres[34] the frames for distribution to DVD (standard definition, SD) and Blu-Ray (high definition, HD). For the time being consumers are not aware of an existing 4K version of these titles, nor have access to them. But when the time comes for studios to release their catalogues in 4K, they will have a relatively easy task to prepare them for public distribution.



[35]

It's worth pointing out that the presentation of these 4K digital restorations are inevitably better than when they were originally premiered in movie theater decades earlier - A time of sub-standard lens optics (from today's vantage point), and were scratches and pops on analog film reels was considered the norm.

Restoration aside, movie production using native 4K digital cameras was introduced long ago by RED Digital Cinema[36] - first with their RED One[37] in 2007, and then with the RED Epic[38] in 2010 supporting 5K (5120x2700) resolution. Founding member and first employee of RED, Ted Schilowitz commented at NAB '13[39] In Las Vegas, "Since we introduced RED back in NAB '07, thousands of movies have been filmed using our cameras. And it's not just Hollywood that's into 4k and 5k production - international studios, and enterprises have joined in as well."

Figure iv - RED One 4K (left) & Epic 5K (right) Digital Cinema Cameras

RED continues to lead the market with their introduction of the RED Dragon, announced on the 8th of April, 2013. This new sensor extends their Mysterium® range to 6K - a sensor that supports 6144x3160 - and has an equivalent resolution to a 19 megapixel camera. The Dragon far exceeds the pixel density of any competing 4K camera from competitors[40] that have recently entered into the UHD production space. Sony is also fighting for market share, with the introduction of their F65[41], claiming an 8K sensor, although the true pixel count is measured around 5782 x 3060[42] (or over 17 million pixels - thus closer to 6K resolution).

Figure v – RED Dragon 6K sensors scheduled for upgrade, at NAB '13 in Las Vegas

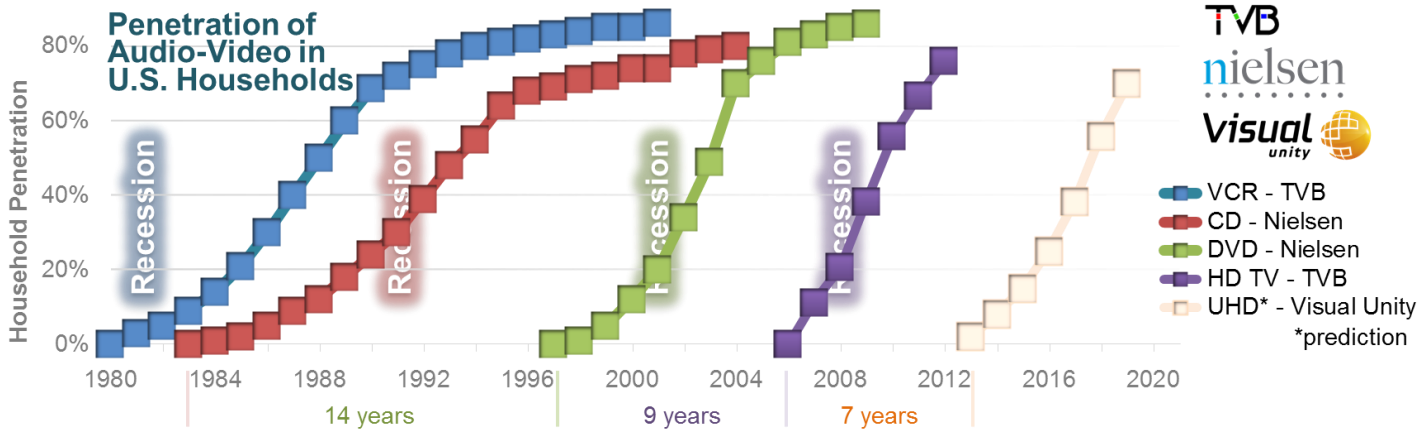


Figure vi – Penetration of Selected Audio & Video Technologies in U.S. Households since 1981

Crossing the 4K Chasm

Likely the first 4K experience for consumers has already been - *or soon will be* - at the cinema. Although most theatres are outfitted with digital projectors using 2K (2048 × 1080)[43], they are steadily upgrading to 4K. As the ultra-high definition experience becomes ubiquitous in theaters, movies produced in UHD will be projected[44] natively, without any reduction or compromises in pixel resolution.

The distribution of 4K content to theaters is an ongoing challenge. With the shadow of piracy looming, content needs to be delivered such that the following contingencies are addressed:

- *Content Delivery* – As the Internet becomes the vehicle to distribute movies to selected cinemas, the appropriate DRM (Digital Rights Management) and encryption mechanisms need to protect the content.
- *Content Storage* – Distributed 4K films require tamperproof hardware to ensure that content is securely protected while at rest.
- *Content Rights* - Centrally established usage policies are needed so that movies are projected at authorized times, and aptly expire - as authorized by the content distributors.
- *Content Quality* – Maintaining consistency in quality through the use of industry certified projectors, screens, optics, and audio quality is essential to ensuring uniformity in the 4K cinema experience. Using the recently ratified H.265 standard will maintain efficiency in file size and bandwidth, while maximizing video quality.

> *The last thing Hollywood needs is pirated 4K content ... downloadable even before a film reaches the theaters.*[45]

Finally, it's worth mentioning the anticipated rate of market adoption of 4K when compared to previous technologies. Studies show that the rate of adoption is increasing with every new technology. The CD[46], took 16 years to reach 70% penetration in U.S. households[47]. It then took six years to reach the same adoption for DVD[48] (introduced in 1998)[49]. HD Television has grown at a similar pace, fuelling Blu-Ray sale in the process. By chance or design as each technology reached 70% penetration, a new format was introduced to consumers (Figure vi). Interestingly, none of the past four recessions adversely affected adoption of these technologies[50]. With the introduction of 4K televisions in 2013, it is entirely feasible for 4K to reach similar adoption rates by the end of this decade.

> *Most certainly, when our walls become gigantic TV monitors ... then HD will be passé, and enthusiasts will be demanding even higher resolutions.*[51]

Before consumers benefit from 4K, its successor is already being showcased. 8K[52] supports resolution up to 7680x4320, and has already been demonstrated by NHK[53], Japan's public broadcasting organization[54]. 8K is essentially equivalent to viewing every single frame in the video at the resolution of a 33 megapixel camera.

When 4K eventually arrives to the living room, consumers will turn their attention to 8K and beyond. HD will be relegated to history class, and on display at the local technology museum.

Read Additional Articles in this Series

I. Consumption is Personal

- http://dusil.com/2013/02/28/consumption-is-personal/

In the days of linear television, broadcasters had a difficult task in understanding their audience. Without a direct broadcasting and feedback mechanism like the Internet, gauging subscriber behavior was slow. Today, online video providers have the ability to conduct a one-to-one conversation with their audience. Viewing habits of consumers will continue to rapidly change in the next ten years. This will require changes in advertising expenditure and tactics.

II. Granularity of Choice

- http://dusil.com/2013/04/01/granularity-of-choice/

The evolution from traditional TV viewing to online video has been swift. This has significantly disrupted disc sales such as DVD and Blu-Ray, as well as cable and satellite TV subscriptions. With the newfound ability to consume content anytime, anywhere, and on any device, consumers are re-evaluating their spending habits. In this paper we will discuss these changes in buying behavior, and identify the turning point of these changes.

III. Benchmarking the H.265 Video Experience

- http://dusil.com/2013/04/22/benchmarking-the-video-experience/

Transcoding large video libraries is a time consuming and expensive process. Maintaining consistency in video quality helps to ensure that storage costs and bandwidth are used efficiently. It is also important for video administrators to understand the types of devices receiving the video so that subscribers can enjoy an optimal viewing experience. This paper discusses the differences in quality in popular video codecs, including the recently ratified H.265 specification.

IV. Search & Discovery Is a Journey, not a Destination

- http://dusil.com/2013/05/13/Search-and-Discovery-Is-a-Journey-not-a-Destination/

Television subscribers have come a long way from the days of channel hopping. The arduous days of struggling to find something entertaining to watch are now behind us. As consumers look to the future, the ability to search for related interests and discover new interests is now established as common practice. This paper discusses the challenges that search and discovery engines face in refining their services in order to serve a truly global audience.

V. Multiscreen Solutions for the Digital Generation

- http://dusil.com/2013/06/24/multiscreen-solutions-for-the-digital-generation/

Broadcasting, as a whole, is becoming less about big powerful hardware and more about software and services. As these players move to online video services, subscribers will benefit from the breadth of content they will provide to subscribers. As the world's video content moves online, solution providers will contribute to the success of Internet video deployments. Support for future technologies such as 4K video, advancements in behavioral analytics, and accompanying processing and networking demands will follow. Migration to a multiscreen world requires thought leadership and forward-thinking partnerships to help clients keep pace with the rapid march of technology. This paper explores the challenges that solution providers will face in assisting curators of content to address their subscriber's needs and changing market demands.

VI. Building a Case for 4K, Ultra High Definition Video

- http://dusil.com/2013/07/15/building-a-case-for-4K-ultra-high-definition-video/

Ultra-High Definition technology (UHD), or 4K, is the latest focus in the ecosystem of video consumption. For most consumers this advanced technology is considered out of their reach, if at all necessary. In actual fact, 4K is right around the corner and will be on consumer wish lists by the end of this decade. From movies filmed in 4K, to archive titles scanned in UHD, there is a tremendous library of content waiting to be released. Furthermore, today's infrastructure is evolving and converging to meet the demands of 4K, including Internet bandwidth speeds, processing power, connectivity standards, and screen resolutions. This paper explores the next generation in video consumption and how 4K will stimulate the entertainment industry.

VII. Are You Ready For Social TV?

- http://dusil.com/2013/08/12/are-you-ready-for-social-tv/

Social TV brings viewers to content via effective brand management and social networking. Users recommend content as they consume it, consumers actively follow what others are watching, and trends drive viewers to subject matters of related interests. The integration of Facebook, Twitter, Tumblr and other social networks has become a natural part of program creation and the engagement of the viewing community. Social networks create an environment where broadcasters have unlimited power to work with niche groups without geographic limits. The only limitations are those dictated by content owners and their associated content rights, as well as those entrenched in corporate culture who are preventing broadcasters from evolving into a New Media world.

IX. Turning Piratez into Consumers, I

- http://dusil.com/2013/10/25/turning-piratez-into-consumers-i/

IX. Turning Piratez into Consumers, II

- http://dusil.com/2014/07/15/turning-piratez-into-consumers-ii/

X. Turning Piratez into Consumers, III

- http://dusil.com/2015/05/12/ott-multiscreen-digital-video-series-10-turning-piratez-into-consumers-iii/

XI. Turning Piratez into Consumers, IV

- http://dusil.com/2015/05/26/ott-multiscreen-digital-video-series-11-turning-piratez-into-consumers-iv/

XII. Turning Piratez into Consumers, V

- http://dusil.com/2015/09/22/ott-multiscreen-digital-video-series-12-turning-piratez-into-consumers-v/

Content Protection is a risk-to-cost balance. At the moment, the cost of piracy is low and the risk is low. There are no silver bullets to solving piracy, but steps can be taken to reduce levels to something more acceptable. It is untrue that everyone who pirates would be unwilling to buy the product legally. It is equally evident that every pirated copy does not represent a lost sale. If the risk is too high and the cost is set correctly, then fewer people will steal content. This paper explores how piracy has evolved over the past decades, and investigates issues surrounding copyright infringement in the entertainment industry.

About the Author

Gabriel Dusil was recently the Chief Marketing & Corporate Strategy Officer at Visual Unity, with a mandate to advance the company's portfolio into next generation solutions and expand the company's global presence. Before joining Visual Unity, Gabriel was the VP of Sales & Marketing at Cognitive Security, and Director of Alliances at SecureWorks, responsible for partners in Europe, Middle East, and Africa (EMEA). Previously, Gabriel worked at VeriSign & Motorola in a combination of senior marketing & sales roles. Gabriel obtained a degree in Engineering Physics from McMaster University, in Canada and has advanced knowledge in Online Video Solutions, Cloud Computing, Security as a Service (SaaS), Identity & Access Management (IAM), and Managed Security Services (MSS).

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Tags

- Connected TV, Digital Video, Online Video, Gabriel Dusil, Internet Video, Broadcast, Linear Broadcast, Multi-screen, Multiscreen, New Media, Online Video Platform, OTT, Over the Top Content, OVP, Smart TV, Social TV, UHD, H.265, H.264, Ultra HD, 4K, 8K, 16K, NHK, RED Epic, RED Dragon, RED One, Sony F65, Canon EOS C500, Mysterium, OLED, HDMI, CES, Consumer Electronics Show, IMAX, HEVC, High Efficiency Video Coding, flexible display

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