
Question 1:
Should CISPR 22 be maintained as the applicable standard for the supply of in-home PLT devices in Australia?

No!

Operation of PLT devices under CISPR 22 limits is technically unfeasible hence a barrier to trade and innovation. Historically not complied with for PLT devices sold in NZ or Australia.

Question 2:
If EN50561-1 is to be adopted, are modifications to the standard necessary to ensure that it is appropriate for Australian conditions?

Yes. Suggested modifications include the following;

Undertake a comparative spectral survey for notched frequencies applied in EU for application in Australia and New Zealand.

Implementing a form of the dynamic spectral management principals of ETSI TR 102 930 – V1.1.1 (referenced in next point) perhaps as an Australian amendment to EN50561, i.e. reducing the PLT transmit levels in the downstream frequency bands of VDSL.

Implementing a static PSD reduction of the PLT transmission spectrum in the downstream frequency bands of VDSL perhaps as an Australian amendment to EN50561. The most common PLT devices on sale in Australia are of Qualcomm Powerline AV2 style chipset and have an uploadable prescaler mask for such spectral shaping purposes. CTI is considering testing the PLT data throughput performance reduction and connection functionality impact of statically notching the VDSL2 B8-16 (998AD E30-M2x-NUS0-A) downstream bands by initially say 20dB in the near future.

As to the TE-003 committees points;

LV power distribution in the EU occurs both underground and overhead not solely underground as alluded to by TE-003. The 50561-1 Standard was implemented knowing that overhead wiring existed and no amendments were included to cater for such areas in Europe.

Whilst the MEN active switching in Australia may present a theoretical concern the user experience has not resulted in any interference complaints. There have been zero reported instances of radio interference from in house PLT devices in Australia received by the ACMA.

Standard ITU broadcast bands such as AM, FM (and Amateur Radio Bands) are statically notched to prevent PLT interference in those frequency bands. The dynamic notching frequency bands include the Short wave (HF) radio broadcasts which are less commonly utilized by consumers. The 15 second validation for dynamic exclusion is based upon the 2007 ETSI plug test. Actually this approach has the acceptance of Radio Broadcast community. The concept was tested and validated in 2007 in an ETSI plug test under the critical supervision of the EBU. Since this plug test the EBU published several statements where they recommend a positive vote on this approach. This led to the approval, in 2008, of ETSI TS 102578, specifying the concept for the first time.
Question 3:
Are you aware of any issues (in overseas jurisdictions) that have been associated with the adoption of EN50561-1 or the operation of in-home PLT devices generally?

No, in fact the IAR Region 1 Newsletter shown above states that; in reference to 50561-1, "It does safeguard the broadcast, amateur and aeronautical frequencies, but spoils the rest of the spectrum for local use. The reason for that is the fairly high emission limit of 110 dBµV." And in reference to 50561-3, "This coming standard will again help to stabilize the situation of PLC coexistence and at least to keep the amateur spectrum clean."

A current search of the internet for complaints related to PLT technology returns no recent results related to PLT and only dated references to Access PLT.

Question 4:
Are you aware of any empirical evidence or field trials in relation to interference between PLT devices and VDSL2 and G.Fast services?

Yes.

Both VDSL2 and G.Fast coexist in Europe along with EN50561-1 compliant PLT devices.

This potential for interference has been recognized by the ITU (International Telecommunications Union) who on 3rd July 2015 established a work item G.9977 titled, "Mitigation of interference between DSL and PLC". The working group status was updated on February 27th 2016.

In October 2015 CTI responded to questions from the ACMA referring to the interference potential between PLT devices and V-VDSDL2 and G.Fast. Additionally the second portion of the document provided included a discussion of co-existence issues which included links to industry and research reports on this topic.

Question 5:
Are you aware of any specific measures that have been successfully implemented (or are being developed) that will offer interference protection to VDSL2 and G.fast from in-home PLT devices?

Yes.

This potential for interference has been recognized by the ITU (International Telecommunications Union) who on 3rd July 2015 established a work item G.9977 titled, "Mitigation of interference between DSL and PLC". The working group status was updated on February 27th 2016.

An ETSI work item currently in early draft form, 'DTS/PLT-00046' titled, "Power Line Telecommunications (PLT) Test Specification for coexistence mechanisms between PLT and VDSL2/G.Fast." Recommendation ITU-T G.9701 (G.fast) specifies a gigabit broadband access technology that exploits the existing infrastructure of copper wires that were originally deployed for POTS services. The present test specification define the tests to evaluate coexistence mechanisms between PLT (SISO and MIMO) and VDSL2 and between PLT (SISO and MIMO) and G.Fast.

Refer to the CTI paper submitted to the ACMA October 2015 for additional references.
Question 6:
Are you aware of any impending developments in PLT technology and/or international standards that may reduce the risk of PLT interference?

Yes.

EN 50561-3:2016 compliance reduces the risk of PLT interference above 30MHz.

Refer to question 5 responses above.

It is agreed that there has been minimal testing of the interference potential arising between BPL and Vectored VDSL and G.Fast services and that the potential for such interference is currently theoretical. However CTI notes that one major supplier of BPL technology, Qualcomm, is now also a major supplier of Vectored VDSL and G.Fast technology and are working towards harmonious integration in order to advance the genesis of IOE, (Internet Of Everything).

Refer to CTI paper submitted in October 2015 which refers to interference potential.

Question 7:
What regulatory or non-regulatory strategies are appropriate to manage consumer awareness risks associated with the operation of PLT devices?

There are no reports of interference from in house BPL devices in Australia. The risk of interference with VDLS2 and G.Fast technology is currently theoretical. Product labelling of the theoretical risk of interference or notification on product websites would seem appropriate.

In advance of implementing the recommendations of working group ITU G9977, just wearing the average interference, if/when it occurs, perhaps with the TELCO using its DSL equipment diagnostics to detect significant cases, could advise the customer of the potential for interference and reduced data transmission rates.

According to ETSI TR 102 930 – V1.1.1
http://www.etsi.org/deliver/etsi_tr/102900_102999/102930/01.01.01/102930v010101p.pdf
DSLAM systems have such capability.


Question 8:
Are there any other matters relating to the supply and use of in-home PLT devices that the ACMA should examine that have not been raised in this paper?

EN 50561-3:2016 has been ratified by CENELEC and published as a British Standard. This Standard applies to the spectrum 30MHz and above with specific limitations below 87.5MHz. This Standard should be adopted along with EN 50561-1:2013.
A reactive stance to ban PLT from use in Australia for the sake of DSL would seem quite excessive and premature whilst the issue is being dealt with at an international level within the ITU and beyond. Companies such as Qualcomm who design and manufacture the majority of Powerline AV PLT integrated circuits deployed in the world also produce V-VDSL and G.Fast technology and have a vision for the IOE Internet Of Everything. It can be expected that the commercial sector will also respond with solutions to the interference issue as they integrate PLT and DSL into customer gateway equipment solutions.

The goal of high speed internet to the home is actually the goal of high speed internet to the user's equipment in the home. The worldwide sales volume of PLT technology to date indicates that PLT is an important part of the in home solution mix for getting internet data to the device for many customers. A scenario of no PLT devices, for homes where Wi-Fi is ineffective would likely mean a rewire of the home for Cat 6, Cat7 or Fibre internet cable. It's a costly scenario to be avoided for similar economic reasons that re-cabling for internet Fibre to the home is presently to be avoided in lieu of fibre to the node.

Of interest Fibre to the home isn’t interfered with by PLT so to discard PLT for the short term solution of vectored DSL (V-VDSL2 and G.Fast) would appear to be economically short sighted given that most telecommunications experts foresee a long term future based upon Fibre to the home. PLT and DSL are both part of the current day solution of high speed internet to the customer within the home and it is CTI's opinion that the issue of cross coupled interference is manageable enabling customers to reap the benefits of high speed data to their in home devices now and into the future.

**Option 1: Status Quo – Compliance with CISPR 22 (No permits)**

Note: This is not the status quo as CTI and numerous other manufacturers currently have a permit to supply a non-compliant device.

CTI strongly disagrees with this option as it limits the application of BPL technology creating a technical barrier to trade and innovation. This effectively bans broadband PLT in Australia and New Zealand to the detriment of the consumer currently relying on the technology because the alternatives ie. Wi-Fi or Cat 6 cabling the home are ineffective or cost prohibitive. Broadband to the house but not to the user devices is ineffectual.

**Option 2: PLT-specific standard – without mandated consumer information**

We proposed and still support the adoption of 50561-1:2013 and 50561-3:2016.

**Option 3: PLT specific standard – with mandated consumer information**

We proposed and still support the adoption of 50561-1:2013 and 50561-3:2016 and would comply with mandated factual consumer information. PLT technology has co-existed with DSL technology for many years. It should be the responsibility of the Telco's who are implementing interference sensitive V-VDSL2 and G.Fast systems, to inform the customers of potential interference and let the customer choose.

**Option 4: Conditional supply – Permit only**

We applaud this process facilitated by the ACMA as an interim solution pending the implementation of a Standards based solution. The permit provides little certainty for suppliers of PLT equipment and for consumers who have found the technology useful, beneficial and reliable as a communication medium.
Technical discussion by Roz Dickson, CTI Assoc Engineer.

In home Broadband PLT and V-VDSDL2 and G.Fast coexistence; A discussion.

Author: R.Dickson
Date: 15-Oct-15

**Introduction**

In home Broadband Powerline data (PLT) is a mature technology capable of achieving Gigabit level data transfers over short distances of mains cable. The technology utilises several methods of modulation such as OFDM and Wavelet and may be thought of as sending multiple tones ranging in frequency from approximately 2Mhz to 100Mhz. The most commonly deployed type in Australia since 2012 is the HomePlug Alliance HomePlug AV2 (IEEE1901 compliant) which utilises spectrum from above the AM radio band at 1.8Mhz through to 67Mhz (below the FM radio band) with notches in its output spectrum to ensure no tones are sent in the Amateur Radio bands. Its broadband predecessor HomePlug AV (2005) had a lower upper frequency limit of 28Mhz. Homeplug Alliance state that over 125 million devices are in the global market and the competing HomeGrid forum based upon ITU G.hn standards forecast shipment volumes of 25 million per year by 2016.

http://www.homeplug.org/tech-resources/techoverview/
http://www.homegridforum.org/content/pages.php?pg=news_press_releases_item&id=188


The ITU standards for G.Fast initially see it utilising spectrum to 106Mhz with a 212Mhz version also available for faster data transfer. V-VDSDL2 delivers data transfer rates up to about 100MBps whilst G.Fast typically achieves hundreds of megabit data rates with the promise of multi Gigabit levels on high quality (new) very short telecommunications cables (approximately 20m).
Commonalities

Of key interest is that both PLT and DSL (Vectored VDSL2 and G.Fast) utilise cables originally intended for slower speed services. PLT on mains cabling intended for power transfer at 50Hz to 60Hz and Vectored DSL and G.Fast on telephone cables intended for voice of up to 3400Hz. Both the mains cables and telephone cables suffer tee offs or bridged taps. The mains wiring within homes typically has many taps occurring at power points and light switches. DSL being fed from the street via telephone lines often has taps at street pits and pillars and also within existing homes with several telephone outlets. Both technologies (PLT and DSL) function far more efficiently without such taps as they greatly disturb the transmission line characteristics impeding data flow. Both PLT and Vectored DSL radiate from their cabling into the environment and both receive broadcast radio signals and unintentional emissions from other’s PLT and DSL systems as both operate in the frequency spectrum traditionally allocated to wireless radio.

Differences

PLT devices are well established, utilising the available broadband in home spectrum of 2Mhz to 100Mhz many years prior to DSL deployments on the same frequencies. PLT was designed with capacity to handle mains borne interference whilst Alcatel-Lucent experienced difficulty in achieving 100Mbps in real world vectored DSL deployments earlier this year because of radiated, coupled mains borne interference from typical home appliances. In response Alcatel-lucent in March 2015 added its support for G.inp (ITU G.998.4), a DSL enhancement to help combat the appliance impulse interference.


Another key difference between PLT and Vectored DSL is in the availability of methods to handle neighbouring network interference. Amongst PLT standards the ITU’s G.hn has the most effective array of neighbouring network noise handling.

http://www.homegridforum.org/uploads/resources/tF6A/4oMq.pdf For managing interference across diverse PLT systems the ISP Inter System Protocol jointly standardised by IEEE in IEEE1901 and ITU-T in G.9972 handles PLT coexistence utilising both spectral shaping and time division to achieve PLT co-existence. http://www.hd-plc.org/modules/press/index.php?page=article&storyid=6 Vectored DSL also has an extensive DSM Dynamic Spectrum Management toolkit relying primarily on the very productive but computationally expensive method of vectoring to reduce self interference within its own cable/ network. Unfortunately at the moment it lacks a standardised means of applying the same to adjacent (isolated) networks. If Vectored DSL is enable to share vectoring information across otherwise isolated technically similar Vectored DSL systems (e.g. multiple DSLAMS of the same brand equipment of different ownership) the vectored noise cancellation technique can be applied across the systems to varying degrees of success (depending upon the size of the networks and other factors).

http://www.huawei.com/us/static/HW-278064.pdf The other tools Vectored DSL has available are transmit power back-off to reduce generated interference and dynamic spectral shaping. Dynamic spectral shaping is most beneficial when the other network or
interfering line isn’t utilising all the same spectral frequency space (for compatibility with slower DSL services only typically using up to 2Mhz to 8Mhz spectrum) or if vectoring is unavailable e.g. VDSL2.

Coexistence issues in homes

As noted both PLT and Vectored DSL utilise the otherwise underutilised radio spectrum located in the home in order to achieve high data transfer rates and are capable of interfering with both radio and each other. VDSL2 and G.Fast are relative new comers to this environment compared to PLT. PLT has long been under the spotlight of groups such as Amateur Radio enthusiasts for doing this particularly because of the unwanted emissions of Access PLT trials whose initial deployments to overhead powerlines contained significant power levels in the Amateur Radio bands. ‘In home’ PLT in Australia hasn’t been the subject of complaints to the ACMA presumably because of a combination of lower transmit power levels (than access PLT) and Amateur Radio notching. The ITU has long been aware that PLT systems radiate into the radio spectrum specifying spectral masks in its G.hn series of PLT standards to minimise it as have the IEEE, FCC and Cenelec who also have measures in place in their standards to achieve similar non-interference outcomes. Of note this year, as Vectored VDSL2 deployments increase and G.Fast becomes deployed commercially the ITU has called for diligence in reporting cases of radio interference generated by such DSL systems. As G.Fast deploy commercially they will have more frequencies in common with radio services than most PLT systems currently deployed. The ITU standards for V-VDSL2 and G.Fast include optional notches for Amateur radio and broadcast radio bands which may be deployed by the service provider on the CPE equipment (the in home DSL modem) in the event of DSL interference to radio services.

http://www.theregister.co.uk/2014/12/08/gfast_at_last_phy_standard_signed_off/

Prior to Vectoring, non Vectored VDSL2 systems were designed to achieve receive signal levels in the home in the home of sufficient magnitude to overcome their self generated far end cross talk (FEXT). At these levels existing in home PLT transmissions caused a minimal level of interference in the average instance to VDSL2 data transfer rates (and vice versa) and so mostly went ignored. The types of cross coupled interference that could occur were examined by ETSI in 2009 at a plugtests event in a simulated home environment and found to depend upon physical cabling of the telephone and mains wiring. Physical separation, length of parallel runs and telecom cable types were determinate of the levels of cross coupled signals. For example a 20m length of Cat3 cable at 0cm spacing gave a cross coupled PSD of -125dBm/Hz and at 6cm spacing yielded a lower -138dBm/Hz, a difference of 13dB. The Cat5 cabling at 0cm spacing was already low at -137 dBm/Hz and lower still at 6cm spacing to -141 dBm/Hz


With DSL Vectoring reducing and nearly perfectly cancelling the VDSL2 (and G.Fast) systems far end self crosstalk the new generation of V-VDSL receivers can now ‘hear’ the crosstalk from the PLT system in the home (i.e. prior to Vectoring its own crosstalk drowned out or masked the PLT signal). Unfortunately the VDSL and G.Fast being able to ‘hear’ the crosstalk...
data transmissions from the PLT doesn’t mean they can understand them or manage their impact. Like the afore mentioned mains borne electrical impulse noise disrupting vectored VDSL2 and the subsequent systems enhancements to better manage their impact (adding G.inp to currently shipping V-VDSL systems in 2015) it would appear there is also a need within Vectored DSL technologies to respond and better manage the impact of the existing mains borne PLT data signals upon their data transfer (noting the HomeGrid Alliance has shipped over 125 million PLT devices globally) or lacking a technical solution, the development of strategies to mitigate the emerging problem.

It would appear that the ITU as the standards organisation for Vectored DSL and also one of the globally accepted PLT standards G.hn has rapidly responded to concerns that existing PLT standards including its own G.hn (for moving data around in a home) are in conflict with the needs of Vectored DSL in getting internet data to the home (because of cross coupling of signals into the last metres of telephone cabling within the home). The ITU have established (Consented on 2015-07-03) work item G.9977 titled ‘Mitigation of interference between DSL and PLC’. The summary reads ‘Recommendation ITU-T G.9977 specifies reference models and functionality of a mechanism to mitigate interference caused by in-home powerline devices to xDSL (implementing access Recommendations like ITU-T G.993.2 and IT-T G-9701) and vise versa.’

Mitigation works

The current ITU works item G.9977 ‘Mitigation of interference between DSL and PLC’ has a referenced document IEEE 1905.1a, titled ‘IEEE Standard for a Convergent Digital Home Network for Heterogeneous Technologies. Amendment 1: Support of New MAC/PHYs and Enhancements’. It has been selected for inclusion to support the objective of the works item with its justification for inclusion reading ‘G.9977 DSL/PLC interference mitigation mechanism makes use of the framing structure of IEEE 1905.1a to communicate AF with ITU-T compliant CPEs and powerline nodes (e.g. ITU-T G.hn)’. So far as which interference mitigation methods will be cooperatively deployed at the physical layers of PLT and DSL such as transmit power back off or dynamic spectral shaping or TDM (time division multiplexing e.g. G.Fast and PLT) it would appear that the G.9977 group hasn’t yet made such information public. A background read as to some of the interference mitigation tools available to DSL can be found in this document titled ‘Dynamic Spectrum Management for Next-Generation DSL Systems’

http://www.princeton.edu/fastcopper/ internal/ reading/dsm2.pdf

ETSI in 2010 published a Technical Report ETSI TR 102 930 V1.1.1 (2010-09) titled ‘PowerLine Telecommunications (PLT); Study on signal processing improving the coexistence of VDSL2 and PLT’

http://www.etsi.org/deliver/etsi_tr/102900_102999/102930/01.01.01_60/ tr_102930v0101 01p.pdf Contained within the report are several measures ranging from static spectral shaping to dynamic spectral shaping of the PLT transmit spectrum. The spectral shaping basically involves reducing the PLT transmit spectrum within the downstream receive bands of the VDSL2 CPE equipment. The report delivers at least one mitigation method, that of
statically altering the PLT transmit spectrum which is valid for use on today’s existing PLT devices. Conceptually the automated dynamic version may be considered as extending the reach of the DSL’s DSM (Dynamic Spectrum Management) into the PLT network in order to apply optimal transmit power backoff and dynamic spectral shaping to the PLT systems transmitters without causing an excessive slowing of the PLT data transfer rate (unfortunately the benefits of interference reduction via DSL vectoring isn’t likely to be used to reduce PLT systems interference).

In line with the ETSI paper’s recommendations and to confirm the feasibility of static PLT spectral reduction the author altered the spectral mask (prescaler) of a pair of typical PowerLine AV2 PLT devices available in Australia (NetCommWireless NP507) reducing their transmit PSD by 20dB in the downlink bands of VDSL2 plan 998ADE30-M2x-NUS0-A and was able to confirm continued data transfer functionality on both a short single phase link of about 4m (including 4 bridged taps of various length) and a cross phase path of tens of meters. Data throughput was reduced by around 50Mbps on the 4m link (to about 250Mbps coded) and halved on the cross phase link (to about 17Mbps coded). For a consumer reliant upon PLT within their home because of the structure of their building precluding the effective use of Wifi (e.g. thick concrete walls, steel frame etc) such mitigation techniques as described by ETSI could likely strike an effective balance between data rates to the home via DSL and data rates within the home via PLT. It’s also likely that only the nearest PLT devices to the telephone cable will need the mitigation strategy as the mains wiring will effectively attenuate the transmit signals from PLT devices more distant within the home.

Given that the cross coupled interference between PLT and DSL is frequency dependent and also time varying with the switching on and off of electrical appliances it’s likely that a dynamic spectral management scheme sharing interference information between DSL and PLT on a tone by tone basis wouldn’t impact the PLT data rate as much as static spectral reduction in achieving the goal of cross system DSL-PLT interference reduction. The same arguments that have seen DSL adopt DSM (Dynamic Spectrum Management) for the sake of optimal data transfer between DSL systems in the same cable bundles (managing DSL cross talk) hold true across DSL and PLT systems. An end to end systems viewpoint of a customer’s home which utilises PLT for in home data transfer and DSL for data to the home would see the optimisation of data rates between the internet to the home via DSL and the distribution of internet and local file transfers/printing within the home via PLT. Dynamic management is the preferred method to accomplish this.

Additional mitigation strategies/resources available.

As mentioned earlier the PLT systems have their ISP Inter-System Protocol (G.9972 and IEEE1901) enabled by default and in the presence of an access PLT system the in-home PLT will vacate the lowest 10 or 14Mhz for use by the access system. If a DSL modem (or it’s mains power supply) were able to emulate the (intentionally computationally simple) ISP protocol tones of an access PLT system onto the mains wiring the 14Mhz bandwidth would be available now for DSL use free of PLT cross coupled signals.
The thesis of Khaled Ali titled “In-home PLC to DSL Interference Characterization and Mitigation” submitted to the University of Calgary in January 2015 focuses upon cooperatively managing PLT to DSL interference and presents two solutions. The first relying on scheduling PLT channel access and the second by pre-multiplying the PLC symbol by the inverse of the DM cross-coupling channel before transmission (a technique that would appear to be similar to that performed by a DSLAM in vectoring i.e. pre compensating for far end crosstalk of DSL at the CPE) [http://hdl.handle.net/11023/2025](http://hdl.handle.net/11023/2025)


**Conclusion**

Multiple methods of interference mitigation between PLT and DSL systems are or could become available however it would appear that the need for interference mitigation was minimal prior to the introduction of vectoring noise reduction technologies to DSL systems. Vectoring is a technology limited to the knowledge of the systems it is working with and it would appear that the authors of the vectoring standards additions to DSL were perhaps naïve to the real world implications of deploying the technology into the home environment with PLT devices or at least limited in their exposure to the issue. A reactive stance to ban PLT from use in Australia for the sake of DSL would seem quite excessive and premature whilst the issue is being dealt with at an international level within the ITU and beyond. Companies such as Qualcomm who design and manufacture the majority of Powerline AV PLT integrated circuits deployed in the world also produce V-VDSDL and G.Fast technology and have a vision for the IOT Internet Of Things. It can be expected that the commercial sector will also respond with solutions to the interference issue as they integrate PLT and DSL into customer gateway equipment solutions.

The goal of high speed internet to the home is actually the goal of high speed internet to the user’s equipment in the home. The worldwide sales volume of PLT technology to date indicates that PLT is an important part of the in home solution mix for getting internet data to the device for many customers. A scenario of no PLT devices, for homes where WiFi is ineffective would likely mean a rewire of the home for Cat 6 internet cable. It’s a costly scenario to be avoided for similar economic reasons that re-cabling a home for internet fibre to the home is presently to be avoided.
Final Points From CTI

Please also bear in mind that there have been no reports of interference from in house PLT devices received by the ACMA.

The future IOE (Internet of Everything) is already developing in Europe where EN50561-1 is accepted and immunity testing of devices is already prerequisite. Qualcomm who develop both PLT and VDSL2 and G.Fast technology support the adoption of EN 50561-1 and EN 50561-3.

It's also important to note that there are over a million PLT users in Australia and these devices have been entrenched in the marketplace for many years now. In respect to the potential for interference with VDSL2 and G.Fast services, whether PLT devices were to comply with CISPR22/32 or EN50561-1&3 their operational noise levels would still overwhelm the vectored services amplitude. Vectored VDSL2 and G.Fast have a co-existence issue with PLT devices that is not new! Perhaps the NBN should acknowledge their responsibility to educate the consumer who can then choose the balance of service they prefer. An existing established product line should not need to forward conform with a newly proposed, operationally conflicting, technology.

CTI applauds the current permit process, agrees with the need to educate the public, and supports the adoption of EN 50561-1:2013 and EN 50561-3:2016 as a Standards based solution to the regulation of in house PLT devices.

Please feel free to contact CTI to discuss any of these points.

Compiled by Scott Franko, April 8th 2016.

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