today @ARIN

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3rd Quarter 2003

ARIN
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Mission Statement

Applying the principles of stewardship, ARIN, a nonprofit corporation, allocates Internet Protocol resources; develops consensus-based policies; and facilitates the advancement of the Internet through information and educational outreach.

ARIN XII - Chicago

NANOG 29 and ARIN meeting hosted back-to-back

For the second time, NANOG and ARIN will be holding back-to-back meetings. At last year's meetings, over 90 people attended both the NANOG and ARIN meetings and we look forward to even more involvement this time!

The NANOG 29 meeting will be held Sunday, Oct. 19 through Tuesday, Oct. 21 and the ARIN XII meeting will be held Wednesday, Oct. 22 through Friday, Oct. 24. The meeting location is the Marriott Chicago Downtown in Chicago, Illinois, US. Information about the meeting can be found at:

http://www.arin.net/ARIN-XII/.

An election to fill the ASO Address Council seat from the ARIN region will take place during the meeting. In additon, the nominees for ARIN's Board of Trustees and Advisory Council will be introduced and given a chance to speak.

Other activities during the meeting include an IPv6 Registration and Policy Tutorial on Tuesday evening, followed by a Policy Proposal BOF.

ARIN would like to thank Server Central for generously agreeing to sponsor the wireless network and terminal room for ARIN XII. ARIN would also like to thank ANET Internet Solutions for its gracious partial sponsorship of the social event.

Note: ARIN will experiment with broadcasting its Public Policy Meetings on Wednesday and Thursday. Multicast services will be provided by University of Oregon and RealNetworks Streaming Video services will be provided by Merit. To view the meeting proceedings remotely, please go to:

http://www.arin.net/ARIN-XII/webcast.html.

IPv4 Address Space - How Long Have We Got?

By Geoff Huston
Telstra

At the time of its original specification some three decades ago the use of a 32-bit address space in the Internet Protocol header was considered to be erring on the side of being outlandish! Contemporary protocols used 16-bit address fields, and in a world of thousands of mainframe computers, it was a leap of faith to believe that 32 bits, or 4 billion addresses, could ever be required, let alone run out.

Yet by the early 90s that's precisely what we were looking at. With the split of the address space into Class A, B, and C networks, it was looking like the Class A space was too large, and Class C space was too small, and the Class B space was still a bit on the large side, but good enough to work with. In that split of the IPv4 address space there were a total of 16,128 Class B networks, and it was pretty obvious in the studies of the early 1990s that the B space would be exhausted by the middle of the decade.

The Internet Engineering Task Force (IETF) embarked on a number of efforts to address this looming problem, and there were two major outcomes. The short-term alleviation was the adoption of Classless Inter-Domain Routing (CIDR), dropping the entire Class A, B, and C address structure, and the longer term effort was to develop the specification of IPv6, a protocol that, among other changes, picked up 128 bit address headers.

Almost a decade later a large amount

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Internet Community Calendar

NANOG 29, October 19-21, 2003, Chicago, Illinois, United States

ARIN XII, October 22-24, 2003, Chicago, Illinois, United States

ICANN, October 27-31, 2003, Carthage, Tunisia

IETF 58, November 9-14, 2003, Minneapolis, Minnesota, United States

LACNIC 5, November 18-20, 2003, Havana, Cuba

Internet Community Meeting Reports

IETF 57
July 13-18, 2003
Vienna, AT

The work of the IETF continues to pull in different directions. Besides a continuing effort to reform itself in response to external and internal forces, the IETF is increasingly involved in issues resulting from proliferation of cell phones using Internet technology. The IETF has also been taking a larger role in defining the protocols that involve registries. This IETF was the least attended in 6 years, and between the previous meeting in SF and this, US attendance fell from 1037 to 462. (No totals were available for other nations.)

ARIN staff attended meetings on IPv6, routing, DNS, registry protocols, and the Internet Engineering and Planning Group. Of particular interest is the progression of the CRISP WG towards a potential replacement of WHOIS and/or RWhois and towards completion of the DNS security extensions.

Additional information is available at:

http://www.ietf.org/meetings/meetings.html.

APNIC 16
August 19-22, 2003
Seoul, KR

The 16th APNIC Open Policy Meeting (APNIC 16) was held in Seoul, Korea between Tuesday 19 August and Friday 22 August. The meeting was hosted by the Korea Network Information Center (KRNIC) and attracted 131 attendees.

Highlights of the meeting included discussion on several policy issues, an ASO AC election for the APNIC region, and discussion related to APNIC database maintenance. Simultaneous Korean-English language translation was available at the meeting, as well as live transcripts. More information about the APNIC 16 meeting is available at:

http://www.apnic.net/meetings/index.html.

RIPE 46
September 1-5, 2003
Amsterdam, NL

The RIPE 46 Meeting was held at the NH Grand Hotel Krasnapolsky from September 1 -5, 2003 in Amsterdam, the Netherlands. Attendees included representatives from the RIPE NCC membership and the RIPE community, as well as staff members from AfriNIC, APNIC, ARIN, and LACNIC.

There were two new working groups at the RIPE 46 Meeting, the RIPE NCC Services WG and the RIPE Address Policy WG. These groups were formed as part of the closing of the old LIR WG. The RIPE NCC General Meeting was held Friday afternoon and among the things discussed were adding two new membership sizes (extra small and extra large), changing the number of votes per membership to one, and reducing the number of RIPE meetings to twice a year.

The RIPE NCC 46 meeting was webcast. Recordings of the sessions have been archived and can be accessed at:

http://www.ripe.net/ripe/meetings/ripe-46/webcast.html.

Further details of the RIPE 46 meeting can be found at:

http://www.ripe.net/ripe/meetings/ripe-46/.

AfriNIC
September 17, 2003
Johannesburg, ZA

The AfriNIC meeting was held in Johannesburg, South Africa on September 19, 2003. This meeting focused on the current status of the emerging AfriNIC Regional Internet Registry (RIR), and noted several significant areas of progress since the last meeting. Decisions regarding location of facilities and staffing have all been finalized and plans for the next steps toward recognition as the fifth RIR are underway.

In addition, ARIN staff met with ISPs from African countries within the ARIN region. The ARIN Internet Resource Policy Evaluation Process was described in conjunction with an open discussion about how ARIN policies impact ISPs in Africa. Resulting from this discussion was a policy proposal collectively submitted by those individuals in attendance. This

policy proposal (2003-15) suggests changes to IPv4 request policies and has been formally submitted into the Internet Resource Policy Evaluation Process for discussion.

More information about the AfriNIC meeting is available at:

http://www.afrinic.org/.

WSIS PREPCOM 3
September 15 - 26, 2003
Geneva, CH

The third preparatory committee meeting for the World Summit on the Information Society (WSIS, 10-12 December 2003, Geneva) was convened in Geneva from 15 to 26 September 2003. Resolution 73 of the International Telecommunication Union (Minneapolis, 1998) resolved to instruct the ITU Secretary-General to place the question of the holding of a World Summit on the Information Society (WSIS) on the agenda of the United Nations Administrative Committee on Coordination (ACC now the United Nations System Chief Executive Board - CEB) and to report to the ITU governing body, the Council, on the results of that consultation. In his report to the 1999 session of the Council on that consultation, the Secretary-General indicated that the ACC had reacted positively and that a majority of other organizations and agencies had expressed interest in being associated with the preparation and holding of the Summit. It was decided that the Summit would be held under the high patronage of the UN Secretary-General, with ITU taking the lead role in preparations. In 2001, the ITU Council decided to hold a Summit in two phases with the first phase to be held from 10 to 12 December 2003, in Geneva, Switzerland and the second from 16 to 18 November 2005 in Tunis, Tunisia. The PREPCOM is to prepare the Declaration and the Action Plan to be discussed at the WSIS. The report from PREPCOM 3 is at http://www.itu.int/wsis/preparatory/prepcom/pc3/index.html.

Further information about WSIS can be found at http://www.itu.int/wsis/basic/about.html.

Of interest to the Internet community is that there are parties that are advocating that the declaration contain language that states that an intergovernmental body will monitor, coordinate and oversee all of the technical and policy activities of the Internet. This would replace the current industry self-regulated model that is in place today. This would cause a change to the current bottom up policy making process in that governments would now be directly involved in policy making and possibly implementation.

2003 Election Information

Board of Trustees and Advisory Council

On July 23, ARIN issued an open call for nominations to fulfill two (2) seats on the Board of Trustees and eight (8) seats on the Advisory Council that will become vacant at the end of this year. All new terms will begin on January 1, 2004. Currently seated Board and AC members may be reelected.

The Board seats opening are currently held by Scott Bradner and John Curran. Both terms will become vacant due to regular term expirations. The two candidates that receive the highest number of votes in this year's election will fulfill three-year terms.

The AC seats opening are currently held by Dana Argiro, Andrew Dul, Dale Finkelson, Avi Freedman, Mark Kosters, Kevin Martin, Lea Roberts, and Stacy Taylor. Five of these seats will become vacant due to regular term expirations. The three remaining seats are open due to resignations and interim appointments. When this year's votes are tallied, the five candidates with the highest number of votes will fulfill full three-year terms. The sixth highest candidate will fulfill a two-year term and the seventh and eighth highest candidates will serve one-year terms.

Information about the election process for the Board of Trustees and Advisory Council is available at http://www.arin.net/elections/. Information about the Board's and AC's purpose, scope, and activities is also available online.

Candidates for ARIN's Board of Trustees

Scott Bradner; John Curran; David Kelly; Paul Vixie

Candidates for ARIN's Advisory Council

Paul Andersen; Leo Bicknell; Dave Diller; Andrew Dul; Dale Finkelson; Mark Kosters; Chris Liljenstolpe; Kevin Martin; Cleveland Mickles; Lea Roberts; Steve Rubin; Robert Seastrom; Stacy Taylor

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of the visible Internet still operates on IPv4. It's been one entire global Internet boom later, and the Internet is over one thousand times larger than it was a decade ago when looking at many metrics. So are we on the brink of address exhaustion?

There are three potential sources of information to look at when seeking to provide an answer to that question. To identify each of these sources it's appropriate to look at the Internet address management process.

Unallocated addresses are maintained by the Internet Assigned Numbers Authority (IANA). The IANA passes blocks of addresses to the Regional Internet Registries, and the address block and date of allocation to the RIR is recorded in the IANA IP Address Registry.

RIRs assign address blocks to ISPs and Local Internet Registries. The address block details and the date of assignment are recorded in the RIR's address registry data. For this exercise the RIR stats files are the most useful registry reports.

ISPs ultimately place address advertisements into the Internet's Inter-Domain Routing system, and these advertisements can be tracked by looking at periodic snapshots of the Global Internet's routing table.

The first table to look at is the current state of IP addresses. Any particular IP address can be in any of six different states (Figure 1):

6% of the address space, or the equivalent of 16 /8 address blocks, is reserved for use within multicast applications. These addresses, from 224.0.0.0 through to 239.255.255.255, are not useable as unicast IPv4 addresses.

7% of the address space, or the equivalent of some 19 /8 address blocks, is reserved by the IETF. These addresses include the upper part of the IP address space, from 240.0.0.0 through to 255.255.255.255, and also include the so-called private address blocks (such as 10.0.0.0/8).

Some 35% of the address space, or the equivalent of 90 /8 address blocks, is currently unallocated. It will be the rate of consumption of this resource that determines how long the IPv4 address space will last into the future.

6% of the address space is currently located in various holding areas within the address allocation process. These addresses include blocks that form part of assignment windows for ISPs and LIRS, as well as blocks passed from IANA to the RIRs that are currently being used for present assignments.

The remaining 46% of the address space has already been assigned for use, and is no longer held in the IANA or the RIRs. 29% of the address space, or the equivalent of some 73 /8 blocks, is visible in the Internet's Internet-Domain routing system.

That leaves 17% of the address space, or the equivalent of some 43 /8 address blocks. These blocks have been assigned to entities at some point, but are not being advertised as reachable on the Internet.

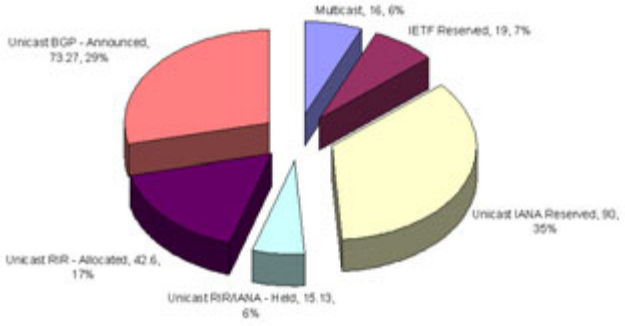


Figure 1 - Status of the IP Address Space

Another way to look at this distribution of address space is to look at the total address space in terms of /8 address blocks (Figure 2).

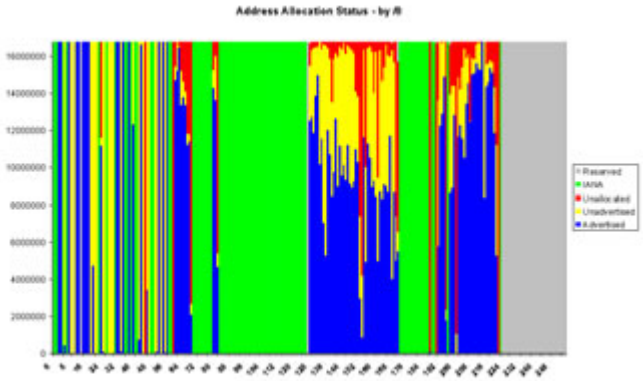
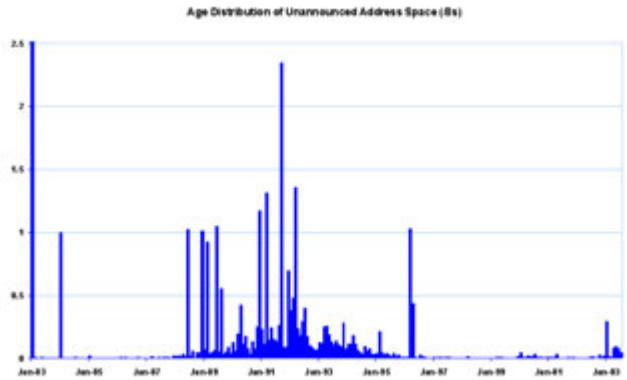


Figure 2 - Status of the IP Address Space by /8 blocks

So in looking at the rate of consumption, the first exercise is to create a model of address consumption, and to do that we need to know a bit more.

Matching the dates of the address space to the unadvertised address pool reveals that the bulk of the unadvertised allocated address space is quite old. It appears that the majority of this space was allocated between 1989 and 1995, and since 1995 this address pool has been relatively constant in size. Over the most recent 3 years it appears to have been getting slightly smaller (Figure 3).

Figure 3 - Age Distribution of unadvertised allocated address space



Looking at the amount of address space held in RIR holding pools, the pool size has expanded slowly. The model appears to be that the pool size increases sharply when an RIR receives a /8 allocation from IANA, and then over the succeeding months the pool size slowly decreases as the addresses are assigned to ISPS and LIRs, and then increases with a further IANA allocation. The outcome is not a clean oscillation, as each RIR operates on a different allocation time cycle with IANA, and the rate of address assignment by the RIRs varies from month to month (Figure 4).

Figure 4 - Address Holding Pool sizes

However, the basic observation is that all RIR-assigned address space becomes visible in the Internet's routing table, and this takes no longer than three months in general from the time of assignment to the time of address advertisement. This leads to the observation that the driving factor behind address consumption is the rate of growth in the address space advertised in the Internet's routing table.

Here there is a wealth of recent data, but a relative paucity of longer term data. Regular hourly counts of advertised address space span back from the present to November 1989. Compared to the 20 years of RIR allocation data in the stats files, this is a relatively short baseline for projections, unfortunately (Figure 5).

Figure 5 - Advertised Addresses in the Internet's Routing Table

The other problem with this data is that there is a strong noise component. Each hour address advertisements appear and disappear, and while it would be expected to have some background level of change, some changes are quite large. Quite surprisingly there are a number of /8 advertisements, spanning some 16.7million host addresses that are quite unstable on an hour-by-hour basis. This makes the generation of a best fit curve to the data quite difficult, and the first exercise is to apply a number of noise reduction filters to the data. First, the number of /8 blocks is set to a fixed number to eliminate the largest amount of noise (Figure 6), and then gradient filters are applied, followed by a smoothing function using a sliding window averaging operation (Figure 7).

Figure 6 - Applying a fixed /8 size to the address data

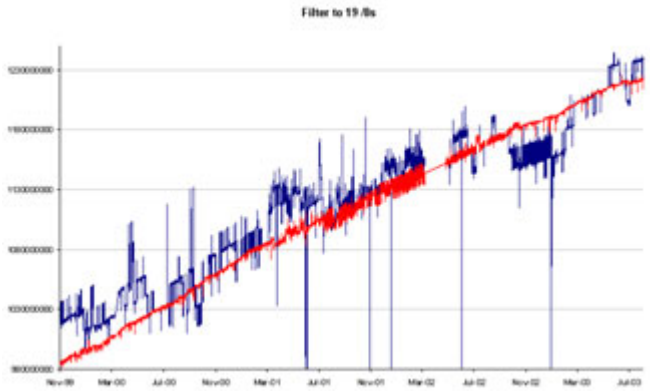
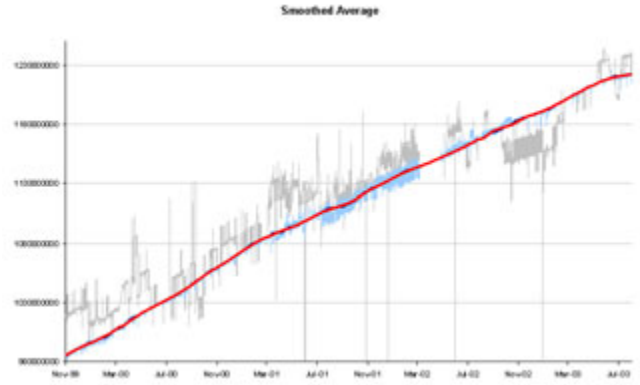


Figure 7 - Smoothed Address Data



Many Internet metrics have a best fit of an exponential curve, where the rate of growth is related to the size of the data set. As the network grows, so does the rate of growth of the particular metric. Surprisingly this is not the case of address consumption over the past four years. The first order differential of the data set shows a pattern which exhibits oscillation (Figure 8), and the best fit is a constant value, rather than a line of positive slope. This correlates to a best fit to the toe data of a linear growth model where the rate of address growth is fixed, irrespective of the size (Figure 9).

Figure 8 - First Order Differential of smoothed data

Figure 9 - Least Squares Linear Best Fit

We are now in a position to model the entire process. Assuming the BGP address table grows at a constant rate of some 4 /8 address blocks per year; the unadvertised address pool continues to shrink at the same rate as measured over the past 4 years; and the RIR holding pools continue to oscillate in size and increase very slowly over this period, then the model will continue to operate for some time (Figure 10).

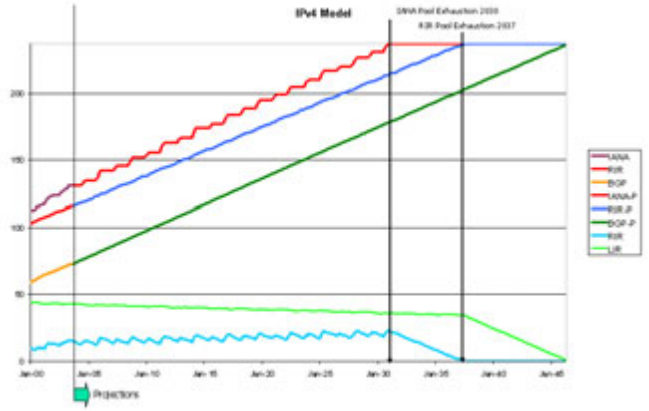


Figure 10 - IP Address Consumption Model and Projections

Projecting the data forward in this model yields the projection that the IANA address pool will exhaust sometime around 2030 and the RIR holding pool will exhaust some 7 years later by 2037, and, assuming that the unadvertised address pool can be recycled into active use in the public Internet and be advertised in the same way as other addresses, then the total pool will exhaust a further ten years later in 2047.

Of course such projections are based on the underlying assumption that tomorrow will be much like today, and the visible changes that have occurred in the past will smoothly translate to continued change in the future. There are some obvious weaknesses in this assumption, and many events will disrupt this prediction.

Some disruptions could be found in technology evolution. Currently much of the Internet is reached via traversal of various network address translation units (NATs) or various forms of application level gateways (ALGs). An upward shift in address take up rates because of an inability of NATs and ALGs to support emerging popular applications is a possibility. If we move from a client server model of networking to a predominate peer-to-peer model the demand for persistent addressing deployments will radically alter address consumption rates. The use of personal mobile IP devices (such as PDAs in their various formats) using public IPv4 addresses would place a massive load on the address space, simply due to the very large volumes associated with deployment of this particular technology.

Other disruptions have a social origin, such as the boom and bust cycle of Internet expansion in the late 1990s and early 2000s. Another form of disruption in this category could be the adoption of a change in the distribution function. The current RIR and LIR distribution model has been very effective in limiting the amount of accumulation of address space in idle holding pools, and in allocating addresses based on efficiency of utilization and conformance to a workable hierarchical model of address-based routing. Other forms of global resource distribution use a geo-political framework, where number blocks are passed to national entities, and further distribution is a matter of local policy (such a system is used in the E.164 number space for telephony). The disruptive nature of such a change would be to immediately increase the number of "holding" points in the distribution system, locking away larger pools of address space from being deployed and advertised and generating a significant upward change in the overall address consumption rates due to an increase in the inefficiency of the altered distribution function.

Another way of looking at this data is to look at the relationship between RIR allocation policies and outcomes in the Internet. In the mid-90s, the RIR system was in place and the policies of this system were, in very general terms, based on conservation of the resource, coupled with the objective of using public address space for the public Internet, and private address space for other non-public environments. Given these general policy objectives, the observed outcome is that this has indeed happened in the Internet. In looking for various uncertainties in the predictive exercise, one major factor is the consistency of RIR assignment policy, and changes in those policies will be reflected in changes in the address consumption rates.

The projection in this exercise is just that - a projection. It's a look at the future based on some trends that appear to exist in today's world. There are many other ways to see the initial projection data, and each will provide different outcomes.

Perhaps the best way of phrasing the outcome of this particular work is that in the near future, and this looks at the next 3 - 5 years of operation of the Internet, there is nothing obvious in what we are doing today that would cause the remaining IPv4 addresses to be rapidly consumed. IPv4 exhaustion, or even critical depletion, does not appear to be a likely event within the near future.

Beyond this period, looking out a decade or even two, the confidence level of the projection is significantly lower in making a comparable prediction. Its certainly possible that the IPv4 address space may fuel Internet growth for some 2, 3, or possibly 4 decades to come, but its hard to see that the Internet will remain locked into a client/server model over that extended period. It may be that a new generation of peer-to-peer applications fuel an industry-wide transition to IPv6, or it may be IPv4 continues to be used at the IP level in the forwarding plane of the network, but IPv4 addresses may be used in conjunction with some other endpoint identification scheme that allows peer-to-peer applications to function transparently while traversing various forms of NATs at the network layer.

So are we running out of V4 addresses? It appears that the best answer that can be offered as an outcome of this exercise is "not just yet."

GEOFF HUSTON holds a B.Sc. and a M.Sc. from the Australian National University. He has been closely involved with the development of the Internet for the past decade, particularly within Australia, where he was responsible for the initial build of the Internet within the Australian academic and research sector. Huston is currently the Chief Scientist in the Internet area for Telstra. He is also a member of the Internet Architecture Board, and is the Secretary of the APNIC Executive Committee. He was an inaugural Trustee of the Internet Society, and served as Secretary of the Board of Trustees from 1993 until 2001, with a term of service as chair of the Board of Trustees in 1999 – 2000. He is the author of several books published by John Wiley & Sons.

The graphs from this article can be viewed at: http://www.arin.net/newsletter/ipv4.html.

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ASO Address Council

On July 18, 2003, ARIN issued an open call for nominations to fulfill the vacancy created by the expiration of Kim Hubbard's term on December 31, 2003. New terms will begin on January 1, 2004.

Information about the election process is available at http://www.arin.net/elections. Information about the ASO AC is available at http://aso.icann.org.

Candidates for the ASO Address Council

Timothy Biggs; Kyle Hamilton; Louis Lee

Important Election Dates

October 15-22
Online voting for the ASO AC election for ARIN members in good standing

October 21-22
Onsite voting for the ASO AC election for all attendees (except RIR staff) of NANOG 29 and ARIN XII.

October 22
Online and onsite ASO AC voting closes at 17:00 ET.

October 23
ASO AC election winner announced during the ARIN XII Public Policy Meeting

October 24
All candidates for the ARIN Board and AC are given the opportunity to present their qualifications

October 27 - November 3
Online voting for the ARIN Board and AC elections for ARIN members in good standing

November 3
Online voting for the Board and AC closes at 09:00 ET

November 10
ARIN President announces Board and AC election winners

ARIN Board of Trustees Actions

The Board of Trustees met on July 21, 2003. They undertook the following actions:

- Approved "The ARIN Election Conflict of Interest List" and agreed to immediately post the list on the ARIN website

- Approved a modification to its Finance Committee's charter

- Appointed David Conrad to serve on the Finance Committee

- Confirmed the appointment of Kim Hubbard to the ASO Address Council

- Approved a definition of the term "current" as relates to its use in Article III, Section 3 of the ARIN Bylaws

- Accepted the ARIN AC's recommendation to adopt Policy Proposal 2002-5: Amnesty Requests, with minor editorial changes

- Accepted the ARIN AC's recommendation to adopt Policy Proposal 2002-6: Aggregation Requests, with minor editorial changes

The complete minutes for this meeting can be found at:
http://www.arin.net/library/minutes/bot/.

ARIN

ARIN Today, a quarterly newsletter, is produced for the ARIN membership and the Internet community. Articles and contributions dealing with IP address issues and technology are welcome from all sources.

Each issue is filled with news highlights, meeting descriptions, policy updates, and information about training and other services ARIN provides its members. Technology news and interesting applications are also covered.

If you have an idea about an article you'd like to submit, or something you'd like to see, please contact the editor at webmaster@arin.net.

The solution to last issue's crossword can be found at http://www.arin.net/newsletter/3rd_solution.html.

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