UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TANKLOGIX, LLC,
Petitioner,

v.

SITEPRO, INC.
Patent Owner.

Case IPR2025-00647

Patent No. 9,898,014

DECLARATION OF DR. ROBERT A. DURHAM

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I, Dr. Robert Durham, Ph.D., hereby declare as follows:

I. INTRODUCTION & QUALIFICATIONS

1. I have been retained on behalf of SitePro, Inc. ("SitePro") to provide my opinions regarding Tanklogix LLC's Petition for *Inter Partes* Review of Claims 1-23 of U.S. Patent No. 9,898,014 ("the '014 Patent"). I submit this declaration based on my personal knowledge and in support of SitePro's Patent Owner Preliminary Response.

2. In formulating my opinions, I have relied upon my knowledge, training, and experience in the relevant art. My qualifications are detailed more fully in my curriculum vitae, which is included as Appendix A. Below, I provide a brief summary of my qualifications.

3. I am being compensated for my time spent in connection with this matter at my usual rate. My compensation is in no way contingent on the substance of my opinions or the outcome of this case.

A. QUALIFICATIONS

4. I am a consulting engineer with experience in a number of technical areas. I have oil and gas industry expertise from drilling and completion to downstream. As a consultant, I have worked with oil field production companies, refining and chemical plants, equipment manufacturers, and technology development companies for over twenty years. My work relates to the subject matter of the ’014 Patent, which I describe below in **Section V** (“Overview of the ’014 Patent”).

5. I received both my Bachelor of Science degree in Electrical Engineering and Master of Engineering and Technology Management degrees from the University of Tulsa in 1992 and 1997, respectively. After years of professional work and research, I received my Ph.D. in Engineering Management from Kennedy Western University in 2004.

6. I have also served in leadership positions in the Petroleum and Chemical Industry Committee (PCIC) of the Institute of Electrical and Electronics Engineers (IEEE) for nearly twenty years. IEEE is the world’s largest technical professional association. The PCIC is the premier forum for the exchange of electrical applications technology related to the petroleum and chemical industry. From 2005 to 2012, I served as Secretary, Vice Chair, and ultimately Chair of the Production Subcommittee of the PCIC. The Production Subcommittee is the primary method for PCIC members to communicate technical papers related to drilling, wellhead, and facilities operations of oil and gas wells. In 2013, I was appointed as Vice-Chair of the Standards Subcommittee of the PCIC, a role which transitioned to Chair in 2014. I served as Chair until 2022. The Standards Subcommittee of the PCIC is the Sponsor of IEEE standards relating to equipment operations in the Oil and Gas Industry. The PCIC Standards Subcommittee sponsors nearly 50 electrical and oil and gas-related standards. In September 2022, I was elected as an Executive Officer of the PCIC. I will serve as an Executive Officer for eight years, holding two-year terms in each position: Secretary, Vice Chair, Chair, and Chair of the Advisory and Awards Committee.

7. My peers have recognized my contributions, particularly in the area of electrical equipment in the oil and gas industry. Because of this recognition, in 2019, I was elevated to the grade of Fellow of the IEEE for "contributions to submersible electrical equipment analysis and multi-point ground methods in hazardous petroleum and chemical environments." The IEEE Fellow grade is limited to the top 0.1% of the IEEE membership worldwide.

8. I have worked directly in the area of electrification of oil and gas fields both as an employee and as a consulting engineer. From 2000 until the end of 2002, I was employed as Manager of Electric Infrastructure for New Dominion, LLC (NDL). In that capacity, I was administratively responsible for all electrical equipment, including overhead power lines, transformers, switchgear, drives, and motors, throughout NDL's production, exploration, and drilling areas.

9. After a brief stint as Vice President for EDG Power Group, where I was responsible for Engineering and Project Management of generation and cogeneration facilities across the U.S., I transitioned to the role of consulting engineer. In that role, I have served as a consulting engineer, designing, constructing, and analyzing various systems, particularly those in the oil and gas industry. This has included the design and selection of equipment, as well as the analysis of equipment failures in the oil and gas field, spanning from drilling and completion sites to production facilities, midstream locations, and downstream (refinery) sites.

10. I am also a Principal of PEDOCS, Inc., an oil and gas production company that has operated over 50 oil and gas production wells in Oklahoma. As such, I am familiar with oil and gas well operations, including well stimulation, completion, hydraulic fracturing, and production.

11. I have been familiar with oil and gas drilling, fracturing (fracking), completion and production operations for nearly twenty years. In addition to being responsible for interfacing with drilling and fracturing operations with regards to electrical needs as an employee of New Dominion, LLC, I have been further educated about drilling, fracturing and operations as I have consulted and investigated incidents on multiple well drilling, fracturing, completion and production sites over my engineering consulting engagements, including numerous water collection, storage and disposal facilities.

12. I have been familiar with power distribution, including generation, transmission, and distribution equipment. As an employee, I worked as a design and construction engineer for generation facilities for Central and Southwest (now

American Electric Power (AEP). I was also responsible for the design and construction of generation facilities when employed by EDG Power Group, as discussed above. While at AEP, I spent three years as a transmission planner, responsible for modeling transmission systems and developing plans for increased power distribution capacities at high voltages. While at New Dominion LLC, I owned and was responsible for the design, construction, and maintenance of several hundred miles of medium-voltage (5–25 kV) distribution lines, switchgear, drives, and motors used for oil and gas drilling, completion, and production. Over the last ~ 20 years, I have consulted with numerous clients, ranging from utilities to oil and gas development and production companies, on the design, upgrades, and maintenance of generation and power distribution facilities.

13. I have been familiar with the design, specification, construction and operation of Adjustable Speed Drive (ASD) systems for over 30 years. While at AEP, I gained my first exposure to ASDs (sometimes referred to as variable frequency drives or VFDs). Between 1990 and 1992, while employed by Public Service Company of Oklahoma (an AEP company), I was responsible for overseeing the field installation of multiple 4,500+ hp VFDs for fans and pumps. I continued working with ASDs and related technologies, such as back-to-back inverter systems, throughout my career at AEP. When I took over as Manager of Electric Infrastructure at New Dominion, I was responsible not only for overhead lines but also for the specification, installation, and operation of all ASDs for production pump applications on both downhole and surface pumping systems. These ASDs ranged from a few hundred to around 1,000 HP at both medium and low voltages. At EDG Power Group, I was responsible for specifying and overseeing the installation of VFDs that ran pumps and fan motors on power generation facility installations. Since I began consulting nearly 20 years ago, I have specified, installed, analyzed, and torn down ASDs on numerous projects. As Standards Chair of the PCIC, I have been responsible for overseeing the management of several standard working groups for ASD applications in the Oil and Gas Industry, including IEEE 1662, 1826, and 1566. I am comfortable in stating that I have worked with several hundred ASDs throughout my career.

14. I have been familiar with control systems, Supervisory Control and Data Acquisition (SCADA) systems, and remote control operations for over thirty years. I have become familiar with web-based control systems over the last decade as part of my various consulting engagements, including drilling systems, fluid handling systems, production systems, and others. I have designed control systems, including remote control, for various facilities throughout my career, including oil and gas production, water storage and disposal facilities, water treatment facilities, power generation plants, generator systems, and aggregate conveying systems, among others. The first control system I designed, for a water treatment facility, was as a junior engineer in 1990-1991. I am a licensed controls system engineer and a licensed petroleum engineer.

15. I am the author or co-author of over fifty published papers and five books. A list of publications that I have written over the last thirty years is included in my professional CV, which is attached as Appendix A.

16. Therefore, based on my education, professional experience of over 30 years, and scholarly books and publications, I am an expert in the relevant field of the ’014 Patent and have been an expert in this field since before the ’014 Patent was filed with the United States Patent and Trademark Office (“USPTO”).

II. TASK SUMMARY AND MATERIALS REVIEWED

17. I have been asked to review the Petition for *Inter Partes* Review of Claims 1-23 of the ’014 Patent along with the associated patent (Ex. 1001), the prosecution history of the ’014 Patent (Ex. 1004), the alleged prior art relied on in Petitioner’s invalidity grounds (Ex. 1005, Ex. 1006), the declaration of Petitioner’s expert, Dr. Wooley (Ex. 1002), and other associated exhibits and provide my opinions regarding the Petition and corresponding documents. In forming my opinions, I have reviewed the materials cited in the List of Exhibits Reviewed (**Section III**, below) and the materials cited throughout my declaration.

18. I reserve the right to respond to anything that may be made available to me in the form of (1) information that may be provided in the expert report(s) of Petitioner's expert witness(s); (2) additional discovery information, such as Petitioner's expert(s)'s report(s) and declaration(s), deposition testimony, document production, etc.; and (3) information obtained through my own investigation. Further, should I not include analysis for certain claim limitations or elements in the sections below, this does not imply that I agree with Petitioner's claim that the limitation or element is anticipated by or obvious over the prior art, nor does it imply that I agree with Dr. Wooley's analysis of the claim limitation or element.

III. LIST OF EXHIBITS REVIEWED

Exhibit No.	Description
1001	U.S. Patent No. 9,898,014 ('014 Patent)
1002	Declaration of Dr. Gary Wooley
1003	Curriculum Vitae of Dr. Gary Wooley
1004	File Wrapper for U.S. Patent No. 9,898,014
1005	US Patent 7,424,399 to Kahn
1006	U.S. Patent No. 9,709,995 to Gutierrez
1007	Fundamentals of Computing With C++
1008	Learning Java, 3rd Edition

1009	Java Threads, 2nd Edition

IV. LEGAL STANDARDS

A. LEVEL OF ORDINARY SKILL IN THE ART

19. When interpreting a patent, I understand that it is important to identify the relevant art pertaining to the patent-in-suit as well as the level of ordinary skill in that art at the time of the claimed invention. The "art" is the field of technology to which the patent is related.

20. I have been instructed by counsel that the person of ordinary skill in the art (**"POSITA"**) is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor's skill is not determinative of the level of ordinary skill. I further understand that the factors that may be considered in determining the level of skill include the types of problems encountered in the art, prior art solutions to those problems, the rapidity with which innovations are made, the sophistication of the technology, and the educational level of active workers in the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

21. I am familiar with how a POSITA would have understood and used the terminology found in the ’014 Patent at the time and before the priority date of the ’014 Patent.

B. Legal Standard for Claim Construction

22. I understand that the first step in determining whether a patent claim would have been anticipated or obvious is to ascertain how a POSITA would have understood the claim terms.

23. I have been instructed by counsel on the law regarding claim construction and patent claims, and I understand that a patent may include two types of claims: independent claims and dependent claims. An independent claim stands alone and includes only the limitations it recites. A dependent claim can depend from an independent claim, or it can further depend from another dependent claim. I understand that a dependent claim includes all the limitations that it recites, in addition to all the limitations recited in the claim(s) from which it depends.

24. It is my understanding that in proceedings before the USPTO, the claims of a patent are to be construed under what is referred to as the “*Phillips* standard.” I understand that this means that the claim terms of a patent are given the meaning the terms would have to a POSITA, in view of the description provided in the patent itself and the patent’s file history.

25. I understand that to determine how a person of ordinary skill would understand a claim term, one should look to those sources available that show what a person of skill in the art would have understood the disputed claim language to mean. I understand that, in construing a claim term, one looks primarily to the intrinsic patent evidence, including the words of the claims themselves, the remainder of the patent, and the patent's prosecution history. I understand that extrinsic evidence, which is evidence external to the patent and the prosecution history, may also be useful in interpreting patent claims when the intrinsic evidence itself is insufficient.

26. I understand that words or terms should be given their ordinary and accepted meaning unless it appears that the inventors were using them to mean something else. In making this determination, the claims, the remainder of the patent, and the prosecution history are of paramount importance. Additionally, the patent and its prosecution history must be consulted to confirm whether the patentee has acted as its own lexicographer (i.e., provided its own special meaning to any disputed terms), or intentionally disclaimed, disavowed, or surrendered any claim scope.

27. In comparing the claims of the '014 Patent to the prior art, I have considered the '014 Patent and its file history in light of the understanding of a person of skill at the time of the alleged invention.

C. ANTICIPATION

28. It is my understanding that a prior art reference anticipates a claim of a patent if each and every element of the claim is found either explicitly or inherently in a single prior art reference or system. I understand that inherency requires a showing that the missing descriptive matter in the claim is necessarily or implicitly present in the allegedly anticipating reference, and that a POSITA would have so recognized it. In addition, I understand that an enabling disclosure is a disclosure that allows a POSITA to make the invention without undue experimentation.

D. OBVIOUSNESS

29. I understand that the prior art may render a patent claim "obvious." I understand that two or more prior art references (e.g., prior art articles, patents, or publications) that each disclose fewer than all elements of a patent claim may be combined to render a patent claim obvious if the combination of the prior art collectively discloses all elements of the claim and one of ordinary skill in the art at the time would have been motivated to combine the prior art in such a way. I understand that this motivation to combine need not be explicit in any of the prior art but may be inferred from the knowledge of one of ordinary skill in the art at the time the patent was filed. I also understand that one of ordinary skill in the art is not an automaton but is a person having ordinary creativity. I further understand that one or more prior art references, articles, patents or publications that disclose fewer than all of the elements of a patent claim may render a patent claim obvious if including the missing element would have been obvious to one of skill in the art (e.g., the missing element represents only an insubstantial difference over the prior art or a reconfiguration of a known system).

30. I understand that under the doctrine of obviousness, a claim may be invalid if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a POSITA to which the subject matter pertains.

31. To assess obviousness, I understand that I am to consider the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and any secondary considerations to the extent they exist.

32. I understand that any evidence of secondary indicia of non-obviousness should be considered when evaluating whether a claimed invention would have been obvious to one of ordinary skill at the time of invention. These secondary indicia of non-obviousness may include, for example:

- a long-felt but unmet need in the prior art that was satisfied by the claimed invention;
- commercial success of processes claimed by the patent;
- unexpected results achieved by the invention;
- praise of the invention by others skilled in the art;

- the taking of licenses under the patent by others; and
- deliberate copying of the invention.

33. I understand that there must be a nexus between any such secondary indicia and the claimed invention.

34. It is also my understanding that there are additional considerations that may be used as further guidance as to when the above factors will result in a finding that a claim is obvious, including the following:

- the claimed subject matter is simply a combination of prior art elements according to known methods to yield predictable results;
- the claimed subject matter is a simple substitution of one known element for another to obtain predictable results;
- the claimed subject matter uses known techniques to improve similar devices or methods in the same way;
- the claimed subject matter applies a known technique to a known device or method that is ready for improvement to yield predictable results;
- the claimed subject matter would have been "obvious to try" choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- there is known work in one field of endeavor that may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to a POSITA;
- there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims; and

- there is some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed subject matter.

35. Finally, I understand that a claim may be deemed invalid for obviousness in light of a single prior art reference, without the need to combine references, if the elements of the claim that are not found in the reference can be supplied by the knowledge or common sense of one of ordinary skill in the relevant art.

E. PRIORITY DATE

36. I understand that, subject to the next paragraph, the asserted "priority date" of a patent is the earlier of: (a) the date on which a patent application is filed; or (b) the date on which an earlier-filed patent application is filed if the patentee claims the benefit of priority to that earlier-filed patent application.

37. I understand that it is not enough for a patent to merely claim the benefit of an earlier-filed application, but that additional criteria must be met. In particular, the prior application itself must describe the claimed invention, and must do so in sufficient detail that one skilled in the art can clearly conclude that the inventor invented the claimed invention as of the filing date sought. First, I understand that a priority-date analysis is on a claim-by-claim basis. Second, I understand that, in order for a patent claim to be entitled to the filing date of an earlier patent application, a "Section 112 analysis" must be conducted. I am informed that a "Section 112" analysis encompasses looking to the earlier patent application, and ascertaining whether that earlier patent application meets both the written-description and enablement requirements as of the filing date of the earlier application. I understand that it is not enough that the claim would have been obvious from the earlier application, but that application itself must describe the claimed invention.

38. I understand that in order to satisfy the written description requirement, the earlier application must reasonably convey to those skilled in the art that the inventors had possession of the subject matter of the patent as of the filing date of the earlier application. I have been informed that it is the disclosures of the earlier patent application that count, and that while the meaning of terms, phrases, or diagrams in the earlier patent application must be interpreted from the vantage point of one skilled in the art, all of the claimed limitations must appear in the specification. Further, I understand that this analysis is not a question of whether one skilled in the art might be able to construct the claimed invention from the teachings of the disclosure. The question is not whether a claimed invention is an obvious variant of that which is disclosed in the specification; rather, I understand that an earlier application must itself describe each of the claim limitations.

39. I also understand that in order to satisfy the enablement requirement, the earlier application must enable a person of ordinary skill in the art to practice the claimed invention without undue experimentation.

V. OVERVIEW OF THE '014 PATENT

A. PATENT SPECIFICATION AND CLAIMS

40. The '014 Patent, entitled "Remote Control of Fluid-Handling Devices," was issued by the USPTO on February 20, 2018.[1] The '014 Patent describes a hosted, web-based, remote industrial monitoring and control system for geographically distributed facilities in oil and gas fields. The system described is designed to receive commands from a user interface, including a web browser, to actuate actuators at an oil and gas facility. The '014 Patent describes several features that enable the system to operate in a hosted web-based environment.

B. PRIORITY DATE

41. I understand that the '014 Patent is a continuation of two prior applications (U.S. App. No. 14/147,190, now U.S. Patent No. 9,342,078, and U.S. App. No. 13/708,557, now U.S. Patent No. 8,649,909) and claims a priority date of December 7, 2012, which is the filing date of U.S. App. No. 13/708,557.[2]

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[1] Ex. 1001 ('014 Patent) cover.

[2] Ex. 1001 ('014 Patent) cover and Petition at 7-8.

VI. OVERVIEW OF PETITIONER'S REFERENCES

A. *KAHN (EX. 1005)*

42. *Kahn* refers to United States Patent No. 7,424,399. *Kahn* is titled "Systems and Methods for Fluid Quality Sensing, Data Sharing and Data Visualization". *Kahn* was filed on June 9, 2006, and issued on September 9, 2008.[3] *Kahn* describes a system for receiving fluid test data generated from sensors in the field and displaying this information to various users via the Internet using graphical user interfaces (GUIs) on user computers.[4] *Kahn* further discloses that the sensors and test data may be controlled by and submitted by multiple different entities. *Kahn* further describes that users affiliated with these various entities, as well as others, may view the submitted data.[5]

B. *GUITERREZ* (EX. 1006)

43. *Gutierrez* refers to United States Patent No. 9,709,995 titled "Chemical Injection System". *Gutierrez* was filed on December 22, 2014, and was issued July 18, 2017. Gutierrez is a continuation of and claims priority to U.S. App. No. 12/794,898 (filed June 7, 2010, which was abandoned), which claims priority to U.S. Provisional Application No. 61/184,890 ("*Gutierrez provisional*", which was

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[3] Ex. 1005 (*Kahn*) cover.
[4] Ex. 1005 (*Kahn*) at Abstract.
[5] Ex. 1005 (*Kahn*) at Abstract.

filed on June 8, 2009). However, I understand that Patent Owner contends that U.S. Patent No. 9,709,995 (i.e., the document referred to as "*Gutierrez*" in the Petition, Dr. Wooley's declaration, and this declaration) is not prior art to the '014 Patent. Importantly, my analysis and expert opinion regarding the disclosure and teaching of *Gutierrez* are directed to the *Gutierrez* document, i.e., U.S. Patent No. 9,709,995. I do not opine whether *Gutierrez* is prior art, or on anything in the *Gutierrez provisional*.

44. *Gutierrez* describes a system that injects chemicals into a pipeline using a pump, a motor, and a reservoir containing the chemical.[6] *Gutierrez's* system uses a motor controller coupled to the pump motor for adapting the motor's rotation speed, which is based on control from a central controller that is in communication with a remote computing device.[7] The central controller is able to translate a signal from the remote computing device to a protocol applicable to the motor controller.[8] *Gutierrez* discloses that the chemical injection system may be controlled by the remote computing device communicating with the injection system via an "enterprise or secure network" such as a virtual private network ("VPN").[9]

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[6] Ex. 1006 (*Gutierrez*) at Abstract.
[7] Ex. 1006 (*Gutierrez*) at Abstract, FIG. 1.
[8] Ex. 1006 (*Gutierrez*) at Abstract, 8:15-26.
[9] Ex. 1006 (*Gutierrez*) 12:55-63.

VII. <u>LEVEL OF ORDINARY SKILL IN THE ART</u>

45. The Petition does not discuss or assert the level that a POSITA would have had at the time of the '014 Patent.[10] Petitioner's expert, Dr. Wooley, asserts that a POSITA "would have had at least a bachelor's degree in engineering (electrical, chemical, or mechanical), computer science, or a related field and significant experience with remotely controlling fluid-handling devices, like SCADA systems."[11] Dr. Wooley does not opine on what "significant experience" means.

46. It is my opinion that a POSITA would have had at least a bachelor's degree in engineering (electrical, chemical, petroleum or mechanical), computer science, or a related field and at least two years of experience designing control systems for remotely controlling fluid-handling devices, like SCADA systems. Alternatively, a POSITA would have had at least six years of experience in designing control systems for remotely controlling fluid-handling devices, such as SCADA systems.

47. I possess both the education requirements and the field experience of a POSITA. Not only is my formal education in the same technical discipline (electrical

[10] *See* Petition, which does not include a section or statement about the level of skill of a POSITA

[11] *See* Ex. 1002 at pg. 9, ¶¶24-25.

engineering) as that of Petitioner's (and my) definition, but I also have additional education beyond a bachelor's degree. Furthermore, I have over thirty years of experience in control system design, including remotely controlling fluid handling devices, as well as SCADA systems. I have over 20 years of experience in oil and gas drilling, completion, and subsurface production operations, including experience with control systems for these operations and associated equipment.

48. For purposes of this declaration, I have applied the level of skill of a POSITA as described above.

VIII. TECHNOLOGY BACKGROUND AND STATE OF THE ART

49. In the subsections below, I describe some of the basic principles of engineering that would be used, or at least considered for use, in the field of oil and gas operations, and particularly in the field of fluid handling during the various stages of drilling, completion, and production. The principles discussed in the subsections below would have been known to a POSITA in the December 2012 timeframe.

50. I understand that it is important, when viewing the State of the Art and the background technology known to a POSITA, to rely on those materials which would have been known to a POSITA at the time of the filing of the '014 Patent. Reliance on materials published or made publicly available after the filing of the

’014 Patent (with the exception of publications specifically documenting the history of an industry) does not show what would have been known to a POSITA in the relevant timeframe.

A. CONTROL SYSTEMS

51. In general, control systems of some variety have been in place since at least the development of water clocks by the Greeks around the 3rd century BC. Automatic control systems for machines were developed in the late 18th century AD, such as the “Watts Fly Ball Governor,” which was developed in 1788.[12] Butz’s Damper Flapper, a precursor to the thermostat, was developed in 1885 and led to the development of Honeywell.

52. Basic control system theory was developed in the early 20th Century, with practitioners such as Bode, Nyquist developing analytical methods such as the Bode plots (a graph of the frequency response of a system) or Nyquist stability criterion, which plots the open-loop (no feedback) response of a system to measure system stability.[13] Minorsky, another mathematician, developed proportional,

[12] https://www.electrical4u.com/control-engineering-historical-review-and-types-of-control-engineering/ (accessed June 25, 2025).
[13] https://www.electrical4u.com/control-engineering-historical-review-and-types-of-control-engineering/ (accessed June 25, 2025).

integral and derivative control (PID) in the 1920s. Heaviside provided mathematical functions that are useful in analytical tools, such as Laplace transforms.

53. In the 1950s, Kalman changed control systems in two significant ways. First, with the development of the "Kalman Filter", a mathematical technique to reduce noise in a measurement system, control systems could be tuned with tighter control, as they would not be responding to noise in the system, but more so to the actual values in the physical system. Second, Kalman developed techniques for representing systems (including control systems) in a matrix form, called a state-space representation. Once in matrix form, the matrices can be manipulated algebraically, rather than relying on calculus-based methods of the PID controller.

54. With the development of the Programmable Logic Controller (PLC) by General Motors on New Year's Day 1968, computers entered the realm of automatic control.[14] A PLC replaced the previous electromechanical devices (relays, pneumatic plunger timers, electromechanical counters, toggle switches, etc.) with solid-state computer-based control. Thus, a control system for a machine that previously may have occupied an entire wall of a room was replaced by a single computer system. The interface with such systems was still through electromechanical devices such as switches, push buttons and pilot lights. Notably, I worked with versions of the first

[14] https://library.automationdirect.com/history-of-the-plc/ (accessed June 25, 2025).

commercially successful PLC, the Modicon 184, in the early years of my career in the late 1980s.

55. By the late 1980s and early 1990s, companies such as Automation Direct and Allen-Bradley (now Rockwell Automation) began creating computer-based interfaces for programming and interfacing with the PLCs. These were referred to as human-machine interface (HMI) displays.

56. Supervisory Control and Data Acquisition (SCADA) systems were developed around the same time as the PLC, in the late 1960s and early 1970s. SCADA systems were used on private networks or systems under complete control of the SCADA system's owners. One example was the SCADA systems for electric utilities that used the 60Hz electric power signal as a carrier to communicate with breakers in the field. SCADA systems were designed to communicate with sensors and equipment in the field, with control being performed by an operator or an automatic loop at the central control station. With the development of Local Area Networks in the 1980s and 1990s, SCADA utilized these technologies to communicate with equipment, such as throughout an entire plant.

57. The integration of these two technologies led to systems such as Gutierrez, where remote control of the system was possible, again through a network controlled entirely by the system's owner (i.e., private networks or VPN).

B. OIL AND GAS WELL DRILLING AND PRODUCTION

58. Oil and gas exploration and production operations depend on identifying, locating and collecting hydrocarbon (i.e., oil and gas (natural gas)) reserves for sale, use as a fuel, lubrication, or for the development of chemicals, pharmaceuticals and plastics used in modern society. For most of human history, petroleum products such as natural asphalts, coal, and surface seeps of oil have been used for various purposes, including paving, construction, waterproofing boats, and as fuel.[15] For the most part, these materials were naturally occurring on the Earth's surface and were collected by simply digging them up and transporting them for use. Some reservoirs of hydrocarbons, however, are located beneath the surface of the earth and must be reached by some well-drilling technique. The first recorded petroleum wells were drilled circa 347 AD during the Jin dynasty in modern-day China.[16] These were percussion-type wells similar to cable tool drilling, widely used in the 1800s. Modern oil and gas production relies heavily on wells drilled to reach hydrocarbon-bearing formations located below the Earth's surface.

59. In 1859, the first commercial oil well in the United States was drilled by Edwin Drake near Titusville, PA. This well was drilled with a cable-tool

[15] (Vassiliou 2018) at xxv - xxvi
[16] (Brewer 2022)

percussion drilling rig and struck oil at a depth of 69 feet.[17] A Cable tool drilling rig uses a heavy chisel-type tool that is suspended from a cable (usually a rope) and repeatedly dropped to chip away at the rock formation. After a certain amount of rock has been chipped, a bucket-type tool (bailer) is lowered to collect and remove the rock chips. The use of cable-tool rigs was widespread through the end of the 19th century, and led to the discovery of many large oil and gas fields in the United States including the NW Pennsylvania fields, Pico Canyon and Los Angeles fields in California, the Neodesha fields in Kansas (Norman No 1), and the Bartlesville-Dewey field in Oklahoma (Nellie Johnstone No. 1).[18]

60. Rotary drilling techniques, where a drill stem is spun and a drill bit cuts into the rock, had been used as far back as the Egyptian era but had limited use until the invention of the roller cone drill bit in 1908 by Howard Hughes. In a rotary drilling system, the drill bit cuts or pulverizes the rock. A fluid, known as drilling mud, is circulated down the hollow drill stem, out of orifices in the bit and then up the annulus, or the area between the drill stem and the wellbore walls. The drill mud serves the dual purpose of lubricating and cooling the bit teeth and grinding surfaces, as well as carrying detritus from the drilling process out of the hole and to the

[17] (Vassiliou 2018) at xxix, 147, 174-175
[18] (Vassiliou 2018) at 149

surface, where it is observed for its characteristics (logged), collected (using shale shakers), and discarded.

61. Traditional well drilling techniques, including both cable tool and rotary methods, focused on maintaining a vertical well and keeping a "straight hole" to reach the target formation at a known location. However, this means that the hydrocarbon-bearing formation is only exposed to the wellbore for the vertical depth of the formation at the wellbore location, which is often only tens of feet. Furthermore, surface drilling locations must be directly above the target formations, limiting access to those formations that are located under geographical features (such as lakes, mountains, oceans), buildings, or other environs that would prevent or make it difficult to locate a traditional drilling pad. In some locations, such as central Oklahoma and the Permian Basin of Texas, vertical wells were spaced every 330 feet above productive formations to effectively drain the formation of hydrocarbons. This resulted in some locations with as many as 196 wells per square mile. Directional drilling (sometimes referred to as horizontal drilling) overcame these shortcomings of traditional oil well drilling.

C. Separation and Storage Facilities

62. Economic production from oil (and natural gas) wells requires the flow of significant volumes of fluid from the wells, to the surface, and then to storage tanks. The fluid from oil wells is typically a three-phase fluid comprising liquid (oil and salt water), gas (methane and other gases) and solids (sand and rock remnants). At the wellhead, these components are part of a single flow stream. For the sale of commercially valuable components (oil and hydrocarbon gases), the three phases are initially separated in a three-phase separator. A three phase separator is a vessel that "slows down" the production stream (often in a pressurized vessel) and allows for settling of the solids to the bottom of the separator (where they are collected and discarded) as well as allowing the gaseous products to "break out" of the liquid stream. The gas is then collected, often compressed, and delivered to a natural gas pipeline for sale or, in cases where no pipeline is available, burned off in a controlled manner using a flare system.

63. The liquid stream, comprised primarily of salt water and oil (along with treating chemicals and other trace minerals), is then delivered to a processing facility, typically on site or near the wellhead, where another settling process separates the oil and salt water, sometimes accelerated by heat. As oil has a lower density than salt water, most of the oil "floats" to the surface of a settling tank (heater treater, gun barrel, free water knockout or other names). The oil is collected and delivered to storage tanks or a pipeline for sale. The saltwater (i.e., produced water) is directed to storage tanks or a pipeline for eventual disposal. In many wells, the volume of produced water is ten times or greater than the volume of produced oil.

64. A typical oil and gas production facility is diagramed in Figure 1.[19]

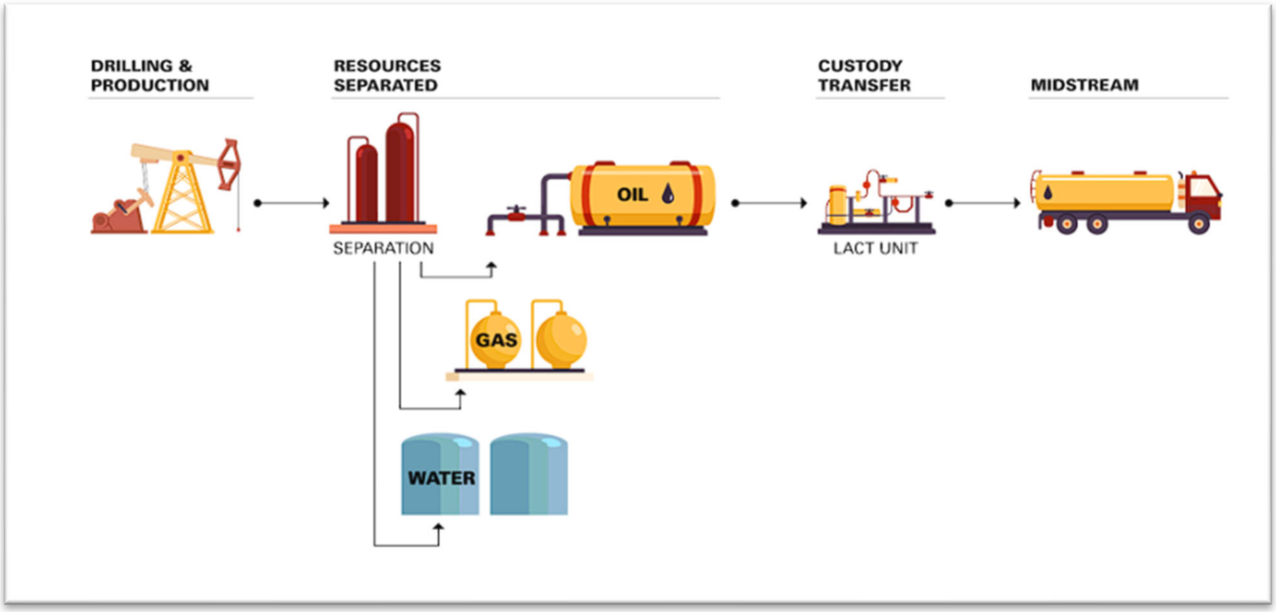

Figure 1 – Typical Oil and Gas Production facility

D. <u>SALT WATER DISPOSAL</u>

65. The most common method of disposal of produced water is re-injection into a disposal, or injection, well. These wells are typically drilled into non-producing (i.e., no commercial oil and gas) that have high permeability, which allows the formation to accept large quantities of fluid. The produced water from the production facility (discussed above) is delivered to the saltwater disposal (SWD) facility either through pipelines or via tank trucks. The produced water typically contains trace amounts of oil which were not collected at the production facility,

[19] Source: https://kimray.com/training/what-does-lact-unit-do

along with the waste brine (salt water). At the SWD facility, the produced water is pumped from the trucks (or the pipeline) into a series of separators and tanks where the skim of oil is collected and stored in oil storage tanks for sale. The remaining saltwater is prepared for injection, typically by running the water stream through filters to process out any remaining sand or other solids. The remaining clean saltwater is then injected into the injection well using large injection pumps. These facilities are typically sized to handle 100,000 bbl. of liquid a day and more.[20] A typical SWD facility is shown in Figure 2, with the primary components of the facility labeled.

[20] A barrel (bbl.) is 42 gallons

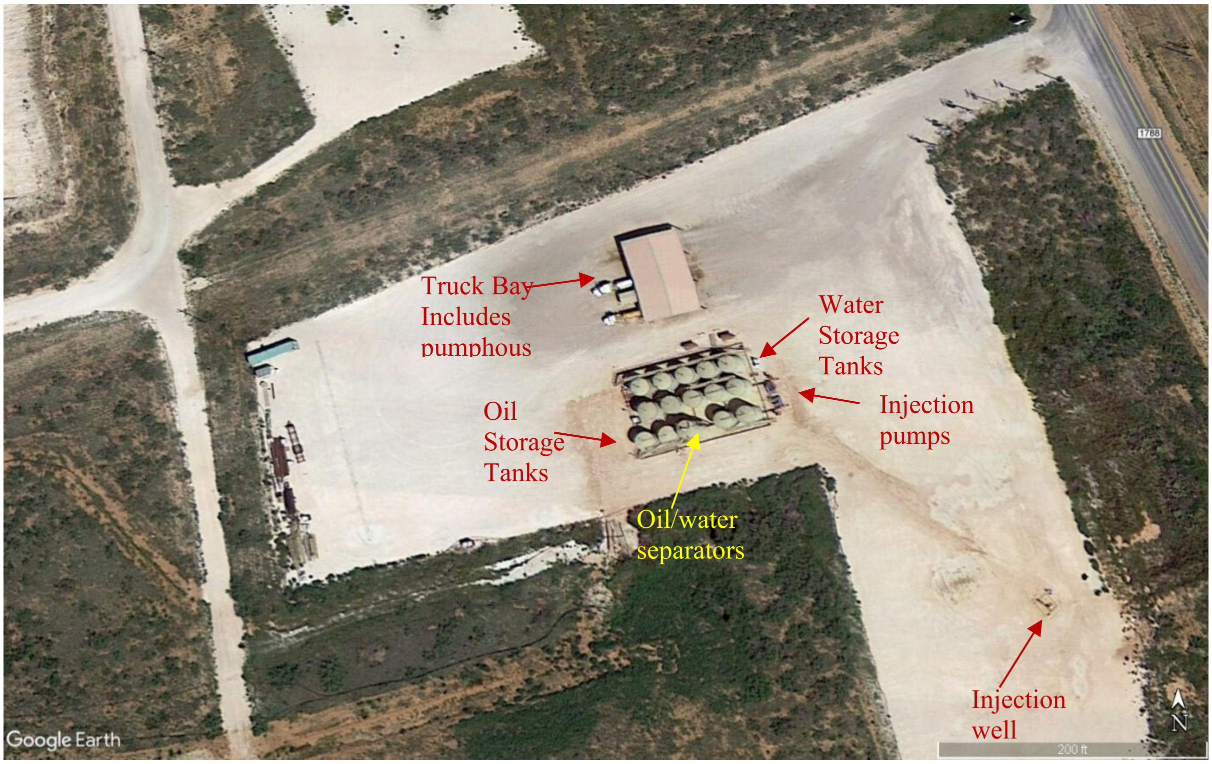

Figure 2- 1788 SWD Facility   31.861538 ºN, 102.201746 ºW (Aug 2017)

E. PETROLEUM PUMPING STATIONS

66. As discussed above, when oil and/or produced water are collected at the production facility, they are stored on-site and then sent off-site for either sale (oil) or disposal (produced water). In many locations, the transportation of these liquids is performed using tank trucks, which collect the liquid at the production facility and then are driven to a SWD facility (for produced water) or a commercial LACT (lease automatic custody transfer) facility.

67. However, in areas of highly concentrated production (e.g., some parts of the Permian Basin), there is sufficient volume of liquid flow to justify the installation of pipeline gathering systems, rather than relying on over-the-road tank trucks. In these locations, the liquid is transported through pipelines via a series of petroleum pumping stations, which handle oil, produced water, or both. These pumping stations, sometimes co-located with storage facilities, add energy to the liquid through the use of pumps and direct the liquid to its proper destination using valves. In these locations, as well as at the production and disposal facilities, sensors are used to determine the properties of the fluid, such as pressure, flow rate, tank level, temperature, and viscosity, allowing the operator to pressurize and direct the flow appropriately. A typical pumping station is shown in Figure 3.[21]

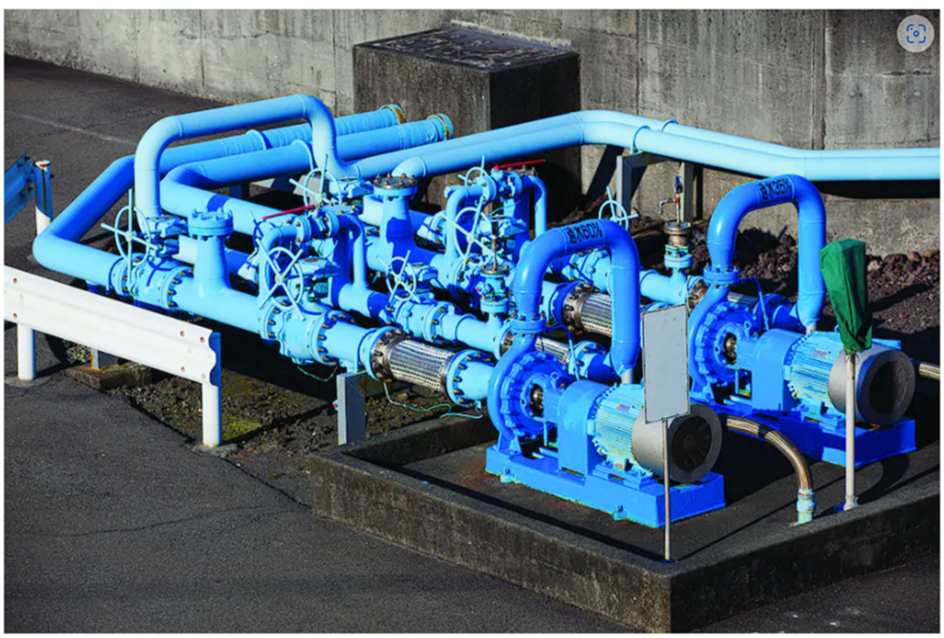

Figure 3 - Petroleum Pump Station

[21] Source: https://www.processingmagazine.com/process-control-automation/instrumentation/article/15586455/fit-the-pumping-technology-to-the-task

F. FLUID HANDLING

68. In each of the locations described above, and in many others, proper operation of the facilities depends on proper handling of the fluids. As mentioned above, many facilities handle as much as 500,000 gallons of fluid every day, or more. Proper operation of these facilities requires the coordination of a system of pumps, valves, storage tanks, and piping systems to move the liquid to its desired destination without damaging the system or creating environmental hazards, such as spills.

69. While the basics of fluid handling (pumps, valves, tanks, pipes) have existed since antiquity, by the time of the ’014 patent, pumps were typically electrically operated, and valves were manually, pneumatically, or electrically operated. Tanks and pipes were constructed of materials suitable for the fluid they were handling (steel for oil, fiberglass, or various plastics for produced or salt water).

70. By the time the ’014 patent was filed, facilities had little to no automation. Production facility pumps were operated continuously or on a timer-based system. Production levels and the overall condition of the facility were typically checked daily by a “pumper,” who would physically drive to each production site within their area of responsibility. Valve positions were usually set manually (or by simple level switches) by the pumper, and tank levels were “gauged” daily to determine production. A SWD facility typically had an on-site operator (e.g., “pumper”) either 24 hours a day or at least daily. This operator would be responsible for starting and stopping pumps as necessary, monitoring tank levels, pressures, and flow rates, and adjusting valves as needed. Some supervisory control and data acquisition (SCADA) systems were available to enable off-site monitoring of equipment; however, these were of limited value due to the lack of communication facilities at the often remote and isolated production and SWD facilities.

IX. CLAIM CONSTRUCTION

71. It is my opinion that a POSITA would understand all the claim terms to have their plain and ordinary meaning, and I have applied the plain and ordinary meaning, in the context of the '014 Patent, for all claim terms.

X. GROUND 1: KAHN DOES NOT ANTICIPATE THE CLAIMS, NOR DOES IT RENDER THE CLAIMS OBVIOUS

72. After review of the evidence submitted in support of the Petition, including the Prior Art relied on and the declaration of Dr. Wooley, it is my opinion that *Kahn* does not render Claims 1, 4-18, and 21-23 of the '014 Patent either anticipated or obvious. There are claim elements and limitations missing from *Kahn* that neither the Petition nor Dr. Wooley show are disclosed, taught or suggested by *Kahn*.

73. As an initial issue, I note that throughout the declaration of Petitioner's expert, Dr. Wooley relies on certain references that fall after the time of the '014 Patent, i.e., later than December 2012. Dr. Wooley does not attempt to show these references are prior art, and in some cases clearly are not prior art on their face, as they have a publication date that postdates the priority date of the '014 Patent.

74. It is my understanding that, when analyzing the patentability of any claim, the person doing the analysis must look at the claims through the lens of a POSITA at the time of the invention (i.e., the priority date). Accordingly, when analyzing the claims of the '014 Patent, Dr. Wooley and I must both look to what a POSITA would have known as of the priority date of the '014 Patent. Despite this, Dr. Wooley points to several pieces of information or references in his declaration that are not prior art references. In at least some examples, the cited information is substantially belated and would not have been understood by a POSITA at the time of the '014 Patent, which raises questions about Dr. Wooley's analysis. These references will be addressed with regard to each claim or limitation for which they are used.

A. INDEPENDENT CLAIM 1

75. It is my opinion that *Kahn* neither anticipates Claim 1 nor renders it obvious. There are key elements of the Claim that are missing from Kahn's disclosure that (1) preclude anticipation and (2) would not have been obvious to a POSITA based on Kahn's disclosure, as discussed in the subsections below.

76. Claim 1 contains the following limitations, which have been subdivided in the same manner that Dr. Wooley and Petitioner subdivided them:

> [1.1] A hosted, web-based, remote industrial monitoring and control system or geographically distributed facilities in oil and gas fields, the system comprising:
>
> [1.2] a computer-implemented datastore storing:
>
> [1.3] a plurality of accounts, each account corresponding to an entity operating one or more geographically distributed oil or gas facilities, the accounts associating different oil or gas facilities with different entities; and
>
> [1.4] network addresses by which industrial monitoring or control equipment at the facilities is accessible via cellular network connections, the monitoring or control equipment including sensors or actuators;
>
> [1.5] a computer-implemented facility-interface module or modules configured to obtain data from the sensors at the facilities and send commands to the actuators at the facilities via the cellular network connections; and
>
> [1.6] a computer-implemented web-interface module or modules configured to send instructions to present control interfaces in web browsers executing on user computing devices logged in to the accounts and to receive commands to control actuators from the user computing devices,
>
> [1.7] wherein the system is configured to receive, with the web-interface module or modules, a user command to actuate an actuator entered via a presented control interface, identify a network address in the datastore corresponding to a facility at which the actuator is located, and send instructions with the facility-interface module or modules to the facility to actuate the actuator, and
>
> [1.8] wherein: the plurality of accounts include a first account, a second account, a third account, and a fourth account;

> [1.9] the first account corresponds to a first group of oil or gas facilities, users of the first account being authorized to send commands to remotely control fluid handling devices at the first group of oil or gas facilities;
>
> [1.10] the second account corresponds to a second group of oil or gas facilities, the first group being different from the second group, users of the second account being authorized to send commands to remotely control fluid handling devices at the second group of oil or gas facilities;
>
> [1.11] the third account corresponds to the first group of oil or gas facilities, users of the third account being authorized to view reports of data from fluid handling devices at the first group of oil or gas facilities; and
>
> [1.12] the fourth account corresponds to the second group of oil or gas facilities, users of the fourth account being authorized to view reports of data from fluid handling devices at the second group of oil or gas facilities.

77. My opinion is in disagreement with Dr. Wooley. I note that though Dr. Wooley makes a conclusory statement in ¶64 that "Claim 1 is anticipated by *Kahn*, or would be obvious to a POSITA in view of *Kahn*," there is no discussion or analysis anywhere in Dr. Wooley's declaration regarding Claim 1 as to *why* the elements not disclosed by *Kahn* would have been obvious to a POSITA at the time of the '014 Patent.

1. **[1.1]: "1. A hosted, web-based, remote industrial monitoring and control system for geographically distributed facilities in oil and gas fields, the system comprising:"**

78. Whether or not the preamble of Claim 1 is afforded any weight in determining patentability of the claim, *Kahn* does not disclose or teach the features stated in the preamble. *Kahn* does not disclose a "remote industrial monitoring and control system" as *Kahn* does not disclose, or even suggest, remote control. *Kahn* is directed toward "sensor systems and methods for fluid monitoring,"[22] not remote control.

79. Dr. Wooley, and Petitioner, point to one portion of *Kahn's* disclosure that initiates "on-site alerts such as optical (indicator lights), audible alerts (e.g. alarm sounds), tactile (e.g., vibration of the unit) or can be interfaced to an appropriate control valve for simply shutting off the supply of fluid upon the detection of emergency events, for instance."[23] However, this does not disclose, teach or even suggest "remote industrial monitoring *and control*" as the claim requires. This brief statement in *Kahn* merely points to *local* indicators (i.e., "on-site alerts) and, at most, "interfacing" these alerts with a local control valve. A POSITA at the time of the '014 patent would understand that local control of a valve could be implemented, for example, by a solenoid valve that would be interfaced with the local sensor's communication unit. A POSITA would not have understood this statement in *Kahn* to mean a remote user would have any control of the control valve for an emergency shut off. Indeed, there is no mention or suggestion of a remote user initiating the shut off of fluid disclosed. There is no disclosure, mention or suggestion of an "industrial monitoring *and control* system".

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[22] Ex. 1005 (*Kahn*) 1:28-29
[23] Ex. 1005 (*Kahn*) 10:62 – 67

80. Further, Dr. Wooley's suggestion that *Kahn's* disclosure that its system "can be used in conjunction with other fluids such as natural gas,"[24] somehow discloses control of "geographically distributed facilities in oil and gas fields," as the claim requires, equally misses the mark. Other than this single statement, *Kahn* discloses a system used in water distribution systems, such as a water utility or commercial water provider. At most, a POSITA may understand this disclosure to suggest use in monitoring a natural gas utility distribution system, similar to the water systems described. However, this is a far cry from disclosing "oil and gas *fields*" as Dr. Wooley suggests. Further, Dr. Wooley provides no discussion or analysis as to *why* the teachings of *Kahn* would render the use of *Kahn's* system in an oil and gas field obvious.

81. Accordingly, *Kahn* does not disclose limitation [1.1], nor would limitation [1.1] have been obvious based on the teachings of *Kahn* as claimed by Dr. Wooley and Petitioner.

2. <u>[1.2]: "a computer-implemented datastore storing:"</u>

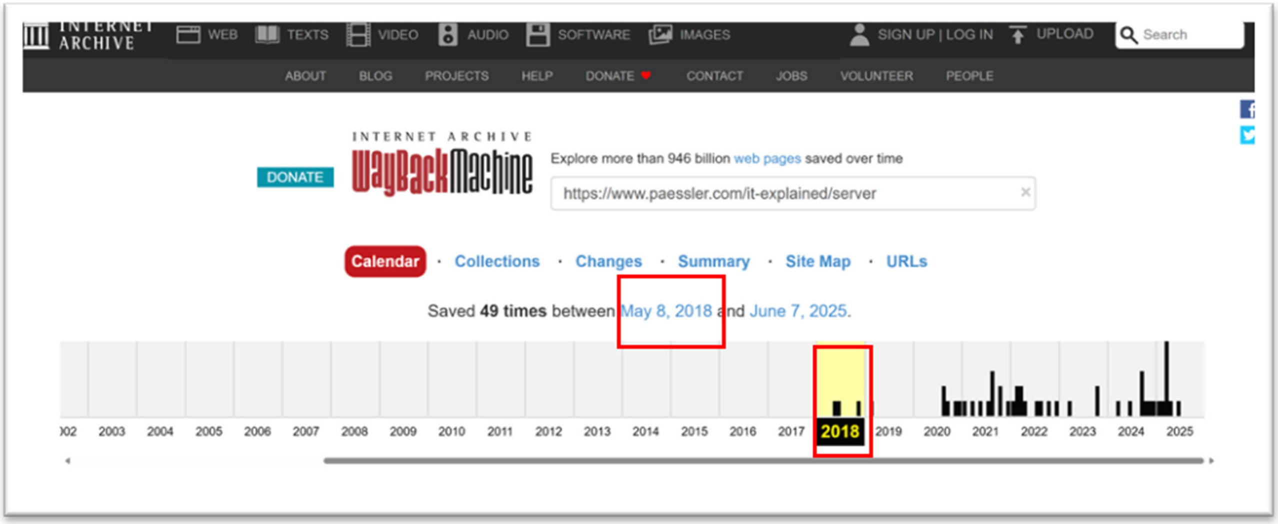
82. Dr. Wooley's analysis does not go to the claimed element. Dr. Wooley points to "storing records, with one or more processors through its disclosure of centralized data collection points"[25] as disclosing a "datastore." However, the claim

[24] Ex. 1005 (*Kahn*) 17:67 – 18:2
[25] Ex. 1002 (*Wooley*) ¶42.

does not require generic memory, but rather a datastore storing specific information, as described in the following limitations. *Kahn's* references to storing "sensor data" at the centralized data collection points do not disclose the specific records the datastore requires. Furthermore, there is no analysis of why the limited disclosure of Kahn would render the limitation obvious; instead, there is only a conclusory statement that *Kahn* discloses the limitation, which it does not.

83. Further, Dr. Wooley points to references that are not prior art in an attempt to show that this limitation is "disclosed" by *Kahn*. However, these are not prior art references, and Dr. Wooley does not attempt to show that they are. In ¶41, Dr. Wooley points to https://www.paessler.com/it-explained/server. However, a visit to the site referenced shows that this is a current reference, with no publication date near the priority date of the '014 Patent. Furthermore, a visit to the Internet Archive (https://web.archive.org/) reveals that this page was not published until at least May 8, 2018.[26]

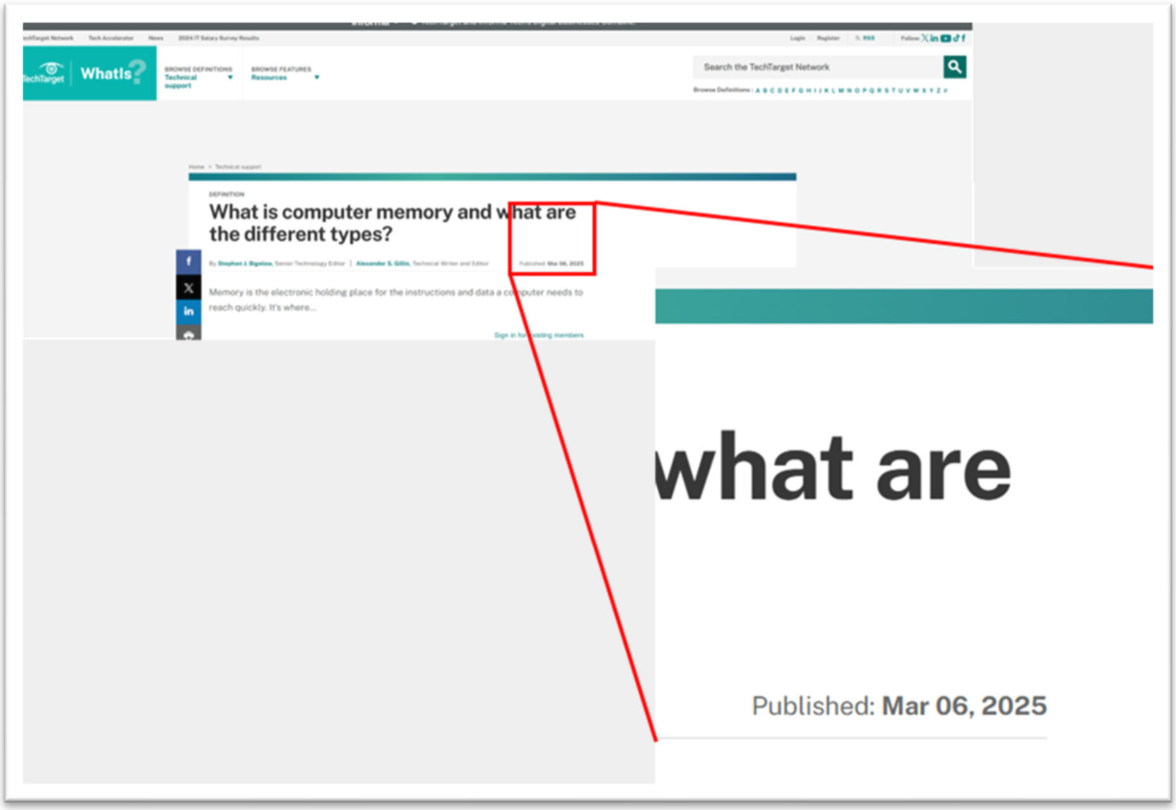
[26] https://web.archive.org/ (accessed June 16, 2025).



Further, Dr. Wooley does not attempt to show that the information contained in the reference would have been known to a POSITA at the time of the ’014 Patent.

84. As another example, Dr. Wooley points to https://www.techtarget.com/whatis/definition/memory. A visit to the referenced site confirms that this is a current reference, with a publication date of March 6, 2025.[27] See the annotated screenshot of the techtarget website cited by Dr. Wooley, showing the publication date. An analysis should be viewed through the lens of a POSITA at the time of the invention, rather than current references.

[27] https://www.techtarget.com/whatis/definition/memory (accessed June 16, 2025).

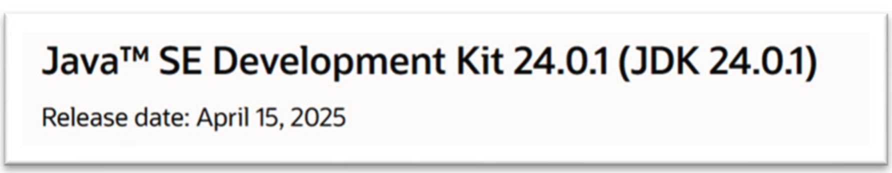


85. Accordingly, *Kahn* does not disclose limitation [1.2], nor would limitation [1.2] have been obvious based on the teachings of *Kahn*.

3. <u>[1.3]: "a plurality of accounts, each account corresponding to an entity operating one or more geographically distributed oil or gas facilities, the accounts associating different oil or gas facilities with different entities; and"</u>

86. Dr. Wooley points to "geographically distributed fluid handling facilities" and "from multiple different entities" as described in *Kahn* to disclose the claimed "geographically distributed oil or gas facilities" and "oil or gas facilities with different entities."[28] However, oil or gas facilities in oil and gas fields, as the entire claim claims, are not disclosed or taught by *Kahn*.[29] Further, Dr. Wooley provides no discussion or analysis as to *why* the teachings of *Kahn* would render the use of *Kahn's* system in an oil and gas field obvious.

87. Again, Dr. Wooley points to references that are not prior art in an attempt to show that this limitation is "disclosed" by *Kahn*. However, these are not prior art references, and Dr. Wooley does not attempt to show that they are. In ¶44, Dr. Wooley points to a Java SE reference: https://docs.oracle.com/javase%2Ftutorial%2F/networking/nifs/definition.html#:~:text=A%20network%20interface%20is%20the,can%20be%20implemented%20in%20software. However, a visit to that page shows no description of a network interface. Further, Java SE 24 was released on April 15, 2025, well after the '014 Patent.[30] See screenshot below.



[28] Ex. 1002 (*Wooley*) ¶¶43 44.
[29] See **Section X.A.1** above regarding limitation [1.1].
[30] https://www.oracle.com/java/technologies/javase/24all-relnotes.html (accessed June 16, 2025).

88. Accordingly, *Kahn* does not disclose limitation [1.3], nor would limitation [1.3] have been obvious based on the teachings of *Kahn*.

4. [1.4]: "network addresses by which industrial monitoring or control equipment at the facilities is accessible via cellular network connections, the monitoring or control equipment including sensors or actuators;"

89. Limitation [1.4] does not merely claim "an address", but a network address which is stored in *the* datastore claimed in limitation [1.2]. In other words, for an anticipation of obviousness analysis, *Kahn* must disclose or teach that the network addresses are contained in the centralized data collection points that Dr. Wooley identifies as the "datastore."[31] *Kahn* makes no such disclosure, nor is there any reference to a network address stored in the data collection point.

90. Dr. Wooley points to a section of *Kahn* (16:40 – 18:52) that discusses the *physical* location of the sensor unit 110, and how the sensors are physically supplied to the various entities using the water. Further, Dr. Wooley points to another section of *Kahn* (11:2-15) that discusses the different physical locations the sensors can be installed such as "a house, business, industrial site or government site, for instance," and "where it is likely that the end user 23 might drink water or otherwise consume or cause fluids to be consumed." These disclosures do not disclose a

[31] See **Section XA.2** above regarding limitation [1.2].

network address at all; at most, they reference a physical *address*. Furthermore, there is no indication that the network addresses are stored in the datastore (i.e., a centralized data collection point). *Kahn* is silent regarding the storage location of network addresses, if any. Further, Dr. Wooley provides no discussion or analysis as to *why* the teachings of *Kahn* would render network addresses in the datastore obvious.

91. Again, Dr. Wooley points to references that are not prior art in an attempt to show that this limitation is "disclosed" by *Kahn*. However, these are not prior art references, and Dr. Wooley does not attempt to show that they are. In ¶44, Dr. Wooley points to the same Java SE reference discussed above regarding limitation [1.3].

92. Accordingly, *Kahn* does not disclose limitation [1.4], nor would limitation [1.4] have been obvious based on the teachings of *Kahn*.

5. [1.5]: "a computer-implemented facility-interface module or modules configured to obtain data from the sensors at the facilities and send commands to the actuators at the facilities via the cellular network connections; and"

93. There are key limitations of the claim that are missing from *Kahn*. As discussed above in limitation [1.1], no remote control (e.g., sending commands to actuators) is disclosed in Kahn, and Dr. Wooley does not attempt to show here that control would have been obvious based on the teachings of *Kahn*.

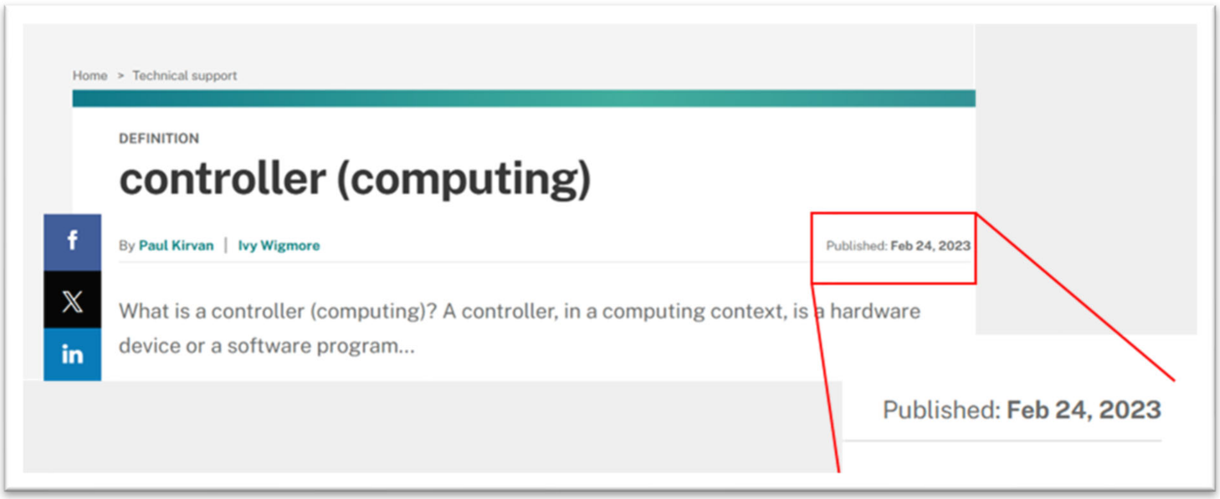
94. Further still, the references that Dr. Wooley points to as "disclosing" the facility interface module do not disclose a facility interface module, but merely are various disclosures of a sensor system with communication. A facility interface module, as a POSITA would understand, would have been a specific module that interfaces between a system's server and the various facilities. There is no description of such a module anywhere in *Kahn*. *Kahn* discloses a "communication unit 112B", which is part of "sensor unit 110."[32] It is unclear to me in the Petition or Dr. Wooley's declaration if that is what Petitioner is mapping to. Regardless, *Kahn's* communication unit is not a facility interface module as recited in Claim 1. Further, Dr. Wooley provides no discussion or analysis as to why the teachings of *Kahn* would render a facility interface module obvious.

95. Again, Dr. Wooley points to references that are not prior art in an attempt to show that this limitation is "disclosed" by Kahn. However, these are not prior art references, and Dr. Wooley does not attempt to show that they are. In ¶46, Dr. Wooley points to https://www.techtarget.com/whatis/definition/controller. A visit to the site referenced shows that this is a current reference, with a publication date of Feb 24, 2023,[33] long after the '014 Patent. See the screenshot of this reference

[32] Ex. 1005 (*Kahn*) 5:61 – 6:2

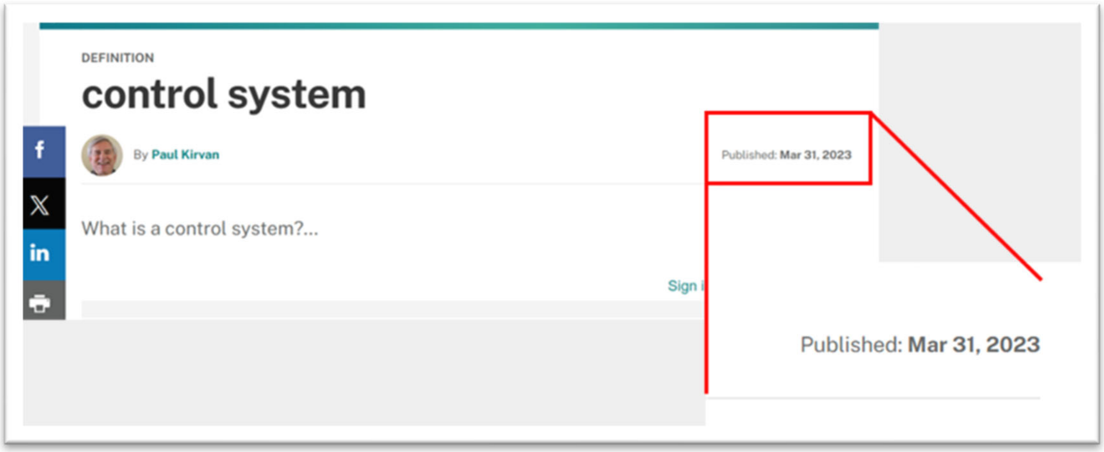
[33] https://www.techtarget.com/whatis/definition/controller (accessed June 16, 2025).

below (annotated to zoom in on the publication date). An analysis of this limitation should look through the lens of a POSITA at the time of the invention, not current references.



Furthermore, in ¶47, Dr. Wooley cites https://www.techtarget.com/whatis/definition/control-system. A visit to the site referenced shows that this also is a current reference, with a publication date of March 31, 2023,[34] again, long after the '014 Patent. See the screenshot of this reference below (annotated to zoom in on the publication date).

[34] https://www.techtarget.com/whatis/definition/control-system (accessed June 16, 2025).

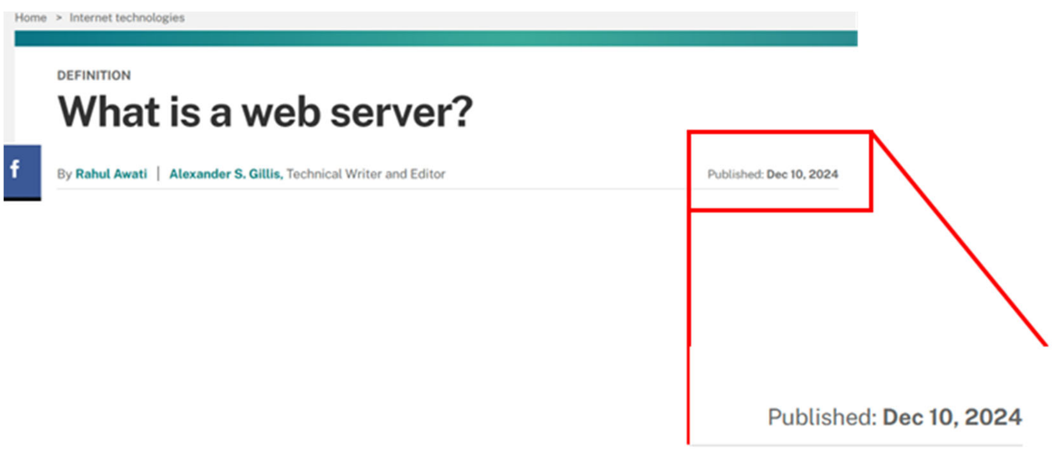


96. Accordingly, *Kahn* does not disclose limitation [1.5], nor would limitation [1.5] have been obvious based on the teachings of *Kahn*.

6. <u>[1.6]: "a computer-implemented web-interface module or modules configured to send instructions to present control interfaces in web browsers executing on user computing devices logged in to the accounts and to receive commands to control actuators from the user computing devices,"</u>

97. As discussed above in **Section X.A.1**, there is no suggestion of remote control in *Kahn*. Further, there is no description or suggestion of a "web-interface module" at all, and certainly no disclosure or suggestion of such a module "configured to send instructions to present control interfaces in web browsers [] and to receive commands to control actuators," as claimed. Further, Dr. Wooley provides no discussion or analysis as to *why* the teachings of *Kahn* would render "receiving commands to control actuators" obvious. As I have discussed above, *Kahn* does not teach remote control, so this cannot be obvious in view of *Kahn's* disclosure.

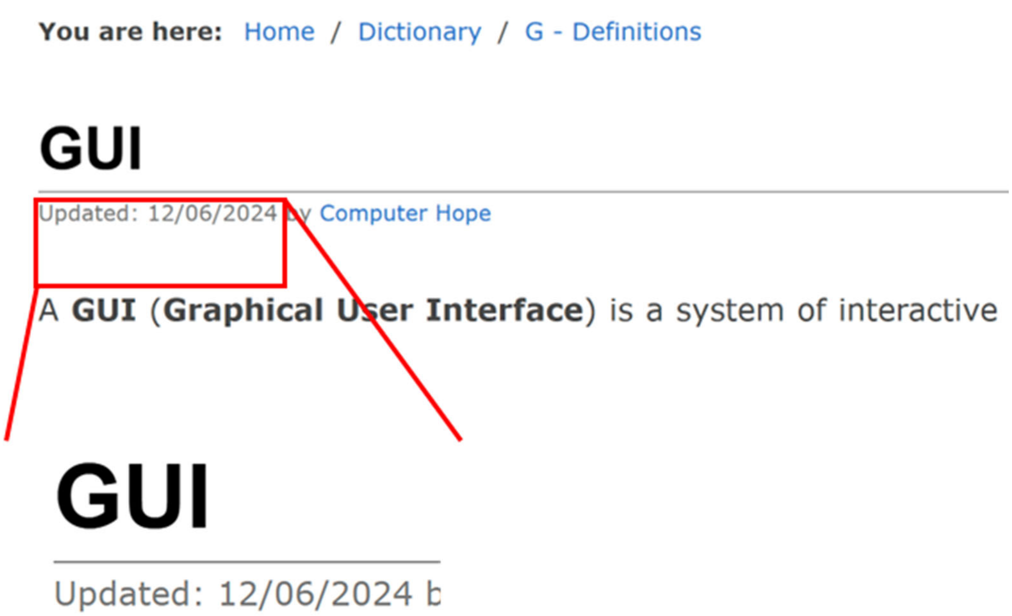
98. Also, like discussed above, Dr. Wooley again points to references that are not prior art in an attempt to show that this limitation is "disclosed" by *Kahn*. However, these are not prior art references, and Dr. Wooley does not attempt to show that they are. In ¶50, Dr. Wooley points to https://www.techtarget.com/whatis/definition/Web-server. A visit to the site referenced shows that this is a current reference, with a publication date of Dec 10, 2024,[35] long after the '014 Patent. See the screenshot of this reference below (annotated to zoom in on the publication date). An analysis of this limitation should look through the lens of a POSITA at the time of the invention, not current references.



99. Further, In ¶51, Dr. Wooley points to https://www.computerhope.com/jargon/g/gui.htm. A visit to the site referenced

[35] https://www.techtarget.com/whatis/definition/Web-server accessed June 16, 2025.

shows that this is a current reference, with a publication date of Dec 6, 2024,[36] long after the '014 Patent. See the screenshot of this reference below (annotated to zoom in on the publication date). An analysis of this limitation should look through the lens of a POSITA at the time of the invention, not current references.



100. Again, In ¶51, Dr. Wooley points to https://www.computerhope.com/issues/ch000619.htm. A visit to the site referenced shows that this is a current reference, with a publication date of June 14, 2025,[37] long after the '014 Patent. See the screenshot of this reference below (annotated to zoom in on the publication date).

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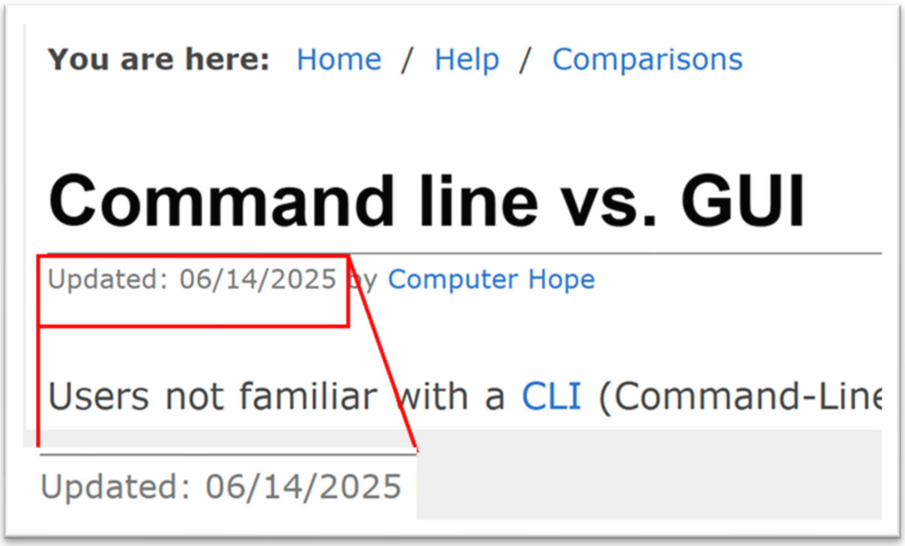
[36] https://www.computerhope.com/jargon/g/gui.htm accessed June 16, 2025.
[37] https://www.computerhope.com/issues/ch000619.htm (accessed June 16, 2025).



101. Accordingly, *Kahn* does not disclose limitation [1.6], nor would limitation [1.6] have been obvious based on the teachings of *Kahn* as claimed by Dr. Wooley and Petitioner.

7. [1.7]: "wherein the system is configured to receive, with the web-interface module or modules, a user command to actuate an actuator entered via a presented control interface, identify a network address in the datastore corresponding to a facility at which the actuator is located, and send instructions with the facility-interface module or modules to the facility to actuate the actuator, and"

102. As discussed above regarding limitations [1.1], [1.5], and [1.6], there is no disclosure anywhere in *Kahn of* "receiving [] a user command to actuate an actuator" or "send instructions [] to the facility to actuate the actuator." *Kahn* is explicitly about remote monitoring using "sensors" and displaying data, not remote control of actuators at the facilities. Furthermore, there is no discussion or disclosure of a network address in the datastore, nor is there any identification of a network address in the datastore, or any disclosure of a facility interface module.[38] Further, Dr. Wooley provides no discussion or analysis as to why the teachings of Kahn would render the missing elements obvious.

103. Accordingly, *Kahn* does not disclose limitation [1.7], nor would limitation [1.7] have been obvious based on the teachings of *Kahn* as claimed by Dr. Wooley and Petitioner.

8. [1.9]: "the first account corresponds to a first group of oil or gas facilities, users of the first account being authorized to send commands to remotely control fluid handling devices at the first group of oil or gas facilities;"

104. This limitation, similar to many others preceding it, requires users "being authorized to send commands to remotely control fluid handling devices at the first group of oil or gas facilities." As discussed repeatedly above, *Kahn* has no disclosure of remotely controlling fluid handling devices, as opposed to merely viewing data collected by sensors or local control. Further, there is no disclosure of "oil or gas facilities" in an oil and gas field, as claimed in Claim 1. Thus, it simply follows that *Kahn* does not disclose an "account" for a user to be authorized to send commands for remote control since *Kahn* does not disclose, teach, or suggest remote

[38] See **Sections X.A.2, X.A.4** and **X.A.5**.

control. Even further, Dr. Wooley provides no discussion or analysis as to *why* the teachings of *Kahn* would render the missing elements obvious.

105. Accordingly, *Kahn* does not disclose limitation [1.9], nor would limitation [1.9] have been obvious based on the teachings of *Kahn* as claimed by Dr. Wooley and Petitioner.

9. [1.10]: "the second account corresponds to a second group of oil or gas facilities, the first group being different from the second group, users of the second account being authorized to send commands to remotely control fluid handling devices at the second group of oil or gas facilities;"

106. Yet again, limitation [1.10] requires "users [] authorized to send commands to remotely control fluid handling devices at the second group of oil or gas facilities." As discussed above regarding limitations [1.9], [1.1], [1.5], and [1.6], there is no disclosure of sending commands, let alone sending commands to oil or gas facilities in an oil and gas field. Thus, there's no disclosure in *Kahn* or teaching by *Kahn* of an authorized user "account" to do so. Further, Dr. Wooley provides no discussion or analysis as to *why* the teachings of *Kahn* would render the missing elements obvious.

107. Accordingly, *Kahn* does not disclose limitation [1.10], nor would limitation [1.10] have been obvious based on the teachings of *Kahn* as claimed by Dr. Wooley and Petitioner.

B. **DEPENDENT CLAIMS 4-18 & 21-23**

108. Claims 4–18 and 21–23 all depend from Claim 1. As multiple limitations from Claim 1 are not disclosed, taught or suggested by *Kahn,* none of the dependent claims are disclosed by *Kahn* or rendered obvious by *Kahn.*

XI. GROUND 2: NEITHER *GUTIERREZ* NOR *GUTIERREZ*, IN VIEW OF KAHN, RENDER THE CLAIMS OBVIOUS.

109. First, it is unclear what Ground 2 was actually intended to be. In Dr. Wooley's declaration, he states that Ground 2 is "*Gutierrez* Anticipates Claims 1-5, 8-10, 12-16, 18-21 and 23 or Would Be Obvious In View of *Gutierrez*."[39] Yet, Dr. Wooley's analysis of the claims seems to imply a combination of *Gutierrez* and *Kahn*, as in ¶122, ¶153 and ¶175, where he states that "Kahn in view of Gutierrez" renders the limitation obvious.[40]

110. In contrast, the petition states that Ground 2 is "*Kahn* in view of *Gutierrez*" without a corresponding *Gutierrez* anticipation ground.[41] Out of an abundance of caution, I will address Dr. Wooley's analysis, which seems to imply some level of anticipation along with the combination of *Kahn* and *Gutierrez*.

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[39] Ex. 1002 (*Wooley*) pg. 58.
[40] Dr. Wooley also states "Gutierrez in view of Kahn" at ¶38. Ex. 1002 (*Wooley*) pg. 21.
[41] Petition 2 pg. 35.

A. THERE WAS NO MOTIVATION TO COMBINE *KAHN* AND *GUTIERREZ*

111. Dr. Wooley claims that a POSITA would be motivated to combine the references because the combination "would have been obvious to try because both references describe similar systems for remote monitoring and control of fluid handling facilities."[42] I disagree. The systems of *Kahn* and *Gutierrez* are fundamentally different. *Kahn* is directed to *displaying*, in a web application, sensor data collected at water handling sites belonging to different entities. As discussed above regarding Ground 1, and incorporated into this analysis by reference, there are no remote-control features in *Kahn*. Thus, Dr. Wooley's statement that both systems have "remote monitoring and control" is simply wrong. *Gutierrez* is a completely different type of system. *Gutierrez* does have both monitoring and control; however, *Gutierrez* is not directed to web-based systems at all.

112. As I discuss further in the analysis of the individual claims below, *Gutierrez* discloses a control and monitoring system on an "enterprise or secured network."[43] Although *Gutierrez* suggests that its disclosures may utilize portions of the Internet, Gutierrez makes it clear that this is through the use of a virtual private network (VPN), rather than a web browser-based system, as disclosed by *Kahn*.[44]

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[42] Ex. 1002 (*Wooley*) ¶124.
[43] Ex. 1006 (*Gutierrez*) 12:55 – 57.
[44] Ex. 1006 (*Gutierrez*) 12:53 – 64.

113. A VPN is a technology that, in addition to keeping a user's identity private and anonymous, allows a user to "tunnel" through the Internet and log in to a private network (such as an enterprise or secure network) as if the user was physically present and connected to the network via a physical cable (or wirelessly, for example using an 802.11 protocol). The key to a VPN is that it is "private". In other words, "[t]he traffic originating and terminating within a private network traverses only those nodes that belong to the private network. Further, there is traffic isolation. That is, the traffic corresponding to this private network does not affect nor is it affected by other traffic extraneous to the private network."[45]

114. Just because a system uses the Internet does not mean it is web-based, as a POSITA would have known in 2012 and even before. As Al-Shahi describes "The terms "internet" (or "the net") and "world wide web" (or "the web") are often used interchangeably as if they were synonymous, without appreciating that the WWW is one of many services available on the internet."[46] The Internet is the physical structure of a global network linking various computers. According to Al-Shahi, "[t]he internet has a hierarchical network structure linked through a backbone of supercomputers permanently joined by high-speed optical cable connections, which traverse land and ocean. Metropolitan Area Networks (MANs) and Wide Area

[45] Appendix B (*Venkateswaran*) pg. 11.
[46] Appendix C (*Al-Shahi* pg. 620).

Networks (WANs) provide higher performance for larger geographical areas, being less dependent on the backbone. Local area networks (LANs) serve organisations."[47]

115. The World Wide Web is a service that displays information on 'pages' in a web browser, such as the figures shown in *Kahn,* using, for example, the hypertext transfer protocol (HTTP).[48] The information is stored on public web servers or other structures that are generally available to anyone with access to the World Wide Web. The specific information on the servers or other structures may be secured.

116. A VPN utilizes the physical infrastructure of the Internet to establish a private network with the same features as if the user were physically connected to the private system. The information is not stored on public web servers or similar structures, but rather on a network of *private* servers. In contrast to servers on the WWW, these private servers are not accessible to anyone outside of authorized users.[49] The distinction between a private network, such as a VPN, and a web-based system is important in understanding the technology behind references such as *Kahn* and *Gutierrez*, as well as the '014 Patent.

[47] Appendix C (*Al-Shahi* pg. 620).
[48] See, e.g., Ex. 1005 (*Kahn*) Fig 8C–8E; 9A–9 B.
[49] A user may interact with a public web server to initiate the VPN tunnel, but once the tunnel is established, it is independent of public web servers.

117. While sharing information, such as that described in *Kahn*, using the www (web-based systems) was well-known and common by the time of the '014 Patent, turning over control of industrial processes to web-based systems was a vastly different endeavor. Web-based systems are substantially more vulnerable to unauthorized access than private-based systems. This is because the packets (bundles of information) used to communicate on the World Wide Web (WWW) are "public"; that is, the packets are routed using public nodes. Although there were encryption protocols (such as secured hypertext transfer protocol "https", which was available in 2012, but not nearly as widely adopted as the present), these were still more vulnerable than VPNs, because "The traffic originating and terminating within a private network traverses only those nodes that belong to the private network. Further, there is traffic isolation. That is, the traffic corresponding to this private network does not affect nor is it affected by other traffic extraneous to the private network."[50]

118. Consider the implications of unauthorized access to the systems of *Kahn* vs. *Gutierrez.* If an unauthorized user accesses Kahn's system, they become aware of the water quality information at various locations. While this would be a concerning breach of security, the physical danger to the system is virtually non-

[50] Appendix B (*Venkateswaran*) pg. 11.

existent. In contrast, unauthorized access to *Gutierrez's* system would at least pose the risk of production loss from the various facilities. At worst, the system could be manipulated to damage the oil field equipment, cause leaks in the system (such as by over pressuring by closing valves with pumps still running) or even result in conflagrations by releasing combustible liquids and flammable vapors, then manipulating electrically driven equipment (such as motor starters, valve controllers, etc.) to create an ignition source. The risks are significantly greater. This is why the art before the ’014 Patent does not show a “web-based” industrial control system, much less one in an oil and gas field.

119. Furthermore, Dr. Wooley attempts to support his supposed motivation with unsupported statements. Dr. Wooley states in a conclusory manner, “A POSITA would understand that the pipelines and transport systems of *Gutierrez* would involve multiple operators and site geographically dispersed site locations, each responsible for the efficient and safe operation of the fluid handling systems.”[51] Dr. Wooley provides no reference from *Gutierrez* to support this because he cannot.

120. Further, Dr. Wooley states, without support, “A POSITA would further understand that supervisors, regulators, etc. would require access to data from the systems, thus different levels of access to data or control of the fluid handling

[51] Ex. 1002 (*Wooley*) ¶125.

systems would be expected by a POSITA."[52] Again, Dr. Wooley provides no support for this statement because he cannot. There is no reference or suggestion in *Gutierrez* of supervisors, regulators, or "different levels of access to data or control" of the fluid handling systems. Further, based on my 30+ years of experience in control systems and 20+ years of experience in oil and gas systems, including control, I cannot imagine a scenario where a "regulator" would be given any access to the "control" of oil and gas field equipment, even in today's environment, and certainly not in 2012 or before. Such a suggestion is certainly not contained anywhere in *Gutierrez* and, on its face, appears nonsensical. *Gutierrez* anticipates only that a single entity will monitor and control equipment owned by that entity and connected by a private network controlled by that entity.

121. Dr. Wooley further erroneously states that a POSITA would not have difficulty combining *Gutierrez* and *Kahn* and that the combination would lead to predictable results because "Gutierrez and Kahn do not describe alternative systems or methods, but rather the disclosure of Kahn merely provides additional detail rather than a different approach to solving problems in the underlying technology."[53] This is simply incorrect. As discussed at some length above, *Gutierrez's* system describes a private network-based system for an individual entity to monitor and control

[52] Ex. 1002 (*Wooley*) ¶125.
[53] Ex. 1002 (*Wooley*) ¶128.

equipment owned by that entity. This is entirely different from Kahn's system, where the public nodes of the web are used to *monitor* sensor data. For a POSITA, it would not be easy or predictable to combine these two different systems. It is only with the hindsight provided by the roadmap of the '014 Patent that a POSITA would have been willing to risk the combination.

B. INDEPENDENT CLAIM 1

122. It is my opinion that *Gutierrez* neither anticipates Claim 1 nor renders it obvious. There are key elements of the claim that are missing from *Gutierrez's* disclosure and have not been shown to be obvious to a POSITA based on *Gutierrez's* disclosure, as discussed in the subsections below. It is further my opinion that *Kahn* fails to demonstrate all of the elements missing from *Gutierrez's* disclosure, or render them obvious. Accordingly, it is my opinion that *Gutierrez, combined with the teachings of Kahn (or vice versa),* does not render Claim 1 obvious.

123. Claim 1 contains the following limitations, which have been subdivided in the same manner that Petitioner and Dr. Wooley subdivided them:

> [1.1] A hosted, web-based, remote industrial monitoring and control system for geographically distributed facilities in oil and gas fields, the system comprising:
>
> [1.2] a computer-implemented datastore storing:
>
> [1.3] a plurality of accounts, each account corresponding to an entity operating one or more geographically distributed oil or gas facilities, the accounts associating different oil or gas facilities with different entities; and

[1.4] network addresses by which industrial monitoring or control equipment at the facilities is accessible via cellular network connections, the monitoring or control equipment including sensors or actuators;

[1.5] a computer-implemented facility-interface module or modules configured to obtain data from the sensors at the facilities and send commands to the actuators at the facilities via the cellular network connections; and

[1.6] a computer-implemented web-interface module or modules configured to send instructions to present control interfaces in web browsers executing on user computing devices logged in to the accounts and to receive commands to control actuators from the user computing devices,

[1.7] wherein the system is configured to receive, with the web-interface module or modules, a user command to actuate an actuator entered via a presented control interface, identify a network address in the datastore corresponding to a facility at which the actuator is located, and send instructions with the facility-interface module or modules to the facility to actuate the actuator, and

[1.8] wherein: the plurality of accounts include a first account, a second account, a third account, and a fourth account;

[1.9] the first account corresponds to a first group of oil or gas facilities, users of the first account being authorized to send commands to remotely control fluid handling devices at the first group of oil or gas facilities;

[1.10] the second account corresponds to a second group of oil or gas facilities, the first group being different from the second group, users of the second account being authorized to send commands to remotely control fluid handling devices at the second group of oil or gas facilities;

[1.11] the third account corresponds to the first group of oil or gas facilities, users of the third account being authorized to view reports of data from fluid handling devices at the first group of oil or gas facilities; and

[1.12] the fourth account corresponds to the second group of oil or gas facilities, users of the fourth account being authorized to view reports of data from fluid handling devices at the second group of oil or gas facilities.

1. **<u>[1.1]: "A hosted, web-based, remote industrial monitoring and control system for geographically distributed facilities in oil and gas fields, the system comprising:"</u>**

124. Whether or not the preamble of Claim 1 is afforded any weight in determining patentability of the claim, *Guiterrez* does not disclose or teach the features stated in the preamble. Dr. Wooley claims that *Gutierrez* discloses this limitation. I disagree. There is no mention of "hosted" or "web-based" monitoring and control systems anywhere in *Gutierrez*. As discussed above in **Section XI.A**, although *Gutierrez* may use portions of the Internet to access a VPN, this is distinct and separate from a hosted, web-based system. Accordingly, limitation [1.1] is not disclosed by *Gutierrez* as Dr. Wooley and Petitioner claim. Dr. Wooley does not look to *Kahn* to fill in the blanks left by *Gutierrez*. My statements above pertaining to *Kahn* are incorporated here for Ground 2.

2. **<u>[1.2]: "a computer-implemented datastore storing:"</u>**

125. Dr. Wooley points to *Gutierrez's* disclosure of "controller 130" as having "data storage" as the datastore claimed. However, [1.2] claims a datastore storing specific information discussed in the limitations below, not generic memory for storing data. There is no suggestion, for example, that the "controller 130", which is a local device located at individual oil and gas sites, would store account information, much less account information "associating different oil or gas facilities with different entities" as stated in limitation [1.3]. Accordingly, the data storage of controller 130 cannot be the datastore claimed.

126. Accordingly, *Gutierrez* does not disclose limitation [1.2] as Dr. Wooley and Petitioner claim.

3. [1.3]: "a plurality of accounts, each account corresponding to an entity operating one or more geographically distributed oil or gas facilities, the accounts associating different oil or gas facilities with different entities; and"

127. Dr. Wooley incorrectly states that "*Gutierrez* discloses a plurality of accounts, namely "geographically distributed fluid-handling facilities"[54] to support his conclusion that *Gutierrez* discloses limitation [1.3]. This is incorrect. The "fluid handling facilities" are not accounts; they are individual "facilities" described in the claims and accessed by the facility interface module discussed in limitation [1.5]. Further, limitations [1.9] and [1.10] claim that the accounts correspond to "groups" of oil and gas facilities. Thus, the claimed accounts are distinct from the facilities. The facilities cannot be both facilities and accounts.

128. Further, *Dr. Wooley* states that "geographically distributed accounts associate fluid-handling facilities from different entities"[55] for two reasons:

- There are multiple fluid-handling facilities and

[54] Ex. 1002 (*Wooley*) ¶133
[55] Ex. 1002 (*Wooley*) ¶133

- There are multiple types of fluid-handling facilities (production sites and pipeline monitoring stations).

129. However, there is no support in *Gutierrez* for either of these arguments. There is no suggestion of facilities being associated with different entities anywhere in *Gutierrez*. In fact, a POSITA would recognize that "enterprise networks" and VPNs are associated with single entities. Further, just because *Gutierrez* describes using its system with multiple types of facilities would not suggest to a POSITA that there are different entities associated with the facilities.

130. In fact, it was a common practice (and still is today) for a single entity to own both production sites and pipeline monitoring facilities (such as a production gathering system for oil or gas). PEDOCS, the production company in which I am a Principal, owned both oil and gas production facilities and pipeline monitoring sites for its oil and gas gathering pipelines.

131. Accordingly, *Gutierrez* does not disclose limitation [1.3] as Dr. Wooley and Petitioner claim.

4. [1.4]: "network addresses by which industrial monitoring or control equipment at the facilities is accessible via cellular network connections, the monitoring or control equipment including sensors or actuators;"

132. Dr. *Wooley* again makes an unsupported conclusory statement that "POSITA would recognize that *Gutierrez* discloses the "addresses for facilities."

However, the word "addresses", much less "network addresses" or any similar term, does not appear anywhere in *Gutierrez*. Dr. Wooley provides no rationale why the sections of *Gutierrez* that he does reference disclose network addresses, much less network addresses stored in the datastore, as claimed. Neither does the petition, as it mirrors Dr. Wooley's declaration, or vice versa.[56] Accordingly, Petitioner does not show that *Gutierrez* discloses or teaches limitation [1.4] as Dr. Wooley and the petition claim.

5. <u>[1.6]: "a computer-implemented web-interface module or modules configured to send instructions to present control interfaces in web browsers executing on user computing devices logged in to the accounts and to receive commands to control actuators from the user computing devices,"</u>

133. Dr. Wooley points to *Gutierrez's* disclosure of a "remote computing system with graphical user interface (GUI)"[57] as a disclosure of limitation [1.6]. However, the claim does not merely claim a "GUI", but rather a distinct set of steps of creating a control interface in web browsers. There are no web browsers or web-interface modules disclosed or suggested in *Gutierrez*. As discussed above in **Section XI.A**, the disclosure of *Gutierrez* is distinct from any use of the World Wide Web.

[56] Petition p. 41-42; Ex. 1002 (*Wooley*) ¶¶134-138.
[57] Ex. 1002 (*Wooley*) ¶141

134. At most, a POSITA would recognize *Gutierrez* as disclosing the use of software located on computer 305 that was used to present a GUI. Such systems were well known at the time of *Gutierrez* and the '014 Patent. I have used such local computer-based software systems to display and control local controllers throughout my career. These systems receive data from a communication system, such as *Gutierrez*, and then present those data in the locally generated GUI for display to an operator. This is a far cry from sending instructions from the web-interface module to a user device to present control interfaces in web browsers. The information supplied by the controller in such systems is the data, not the instructions. The instructions to present the displayed data are generated by the local GUI software. There is simply no suggestion of the claimed arrangement in *Gutierrez*.

135. Accordingly, *Gutierrez* does not disclose limitation [1.6] as Dr. Wooley and Petitioner claim.

6. [1.7]: "wherein the system is configured to receive, with the web-interface module or modules, a user command to actuate an actuator entered via a presented control interface, identify a network address in the datastore corresponding to a facility at which the actuator is located, and send instructions with the facility-interface module or modules to the facility to actuate the actuator, and"

136. As discussed above regarding limitation [1.6], there is simply no suggestion of a web-interface module in *Gutierrez*. Therefore, it clearly follows that

Gutierrez's system cannot receive, with a web-interface module, user commands to actuate an actuator as required in limitation [1.7].

137. Accordingly, *Gutierrez* does not disclose limitation [1.7] as Dr. Wooley and Petitioner claim.

C. DEPENDENT CLAIMS 4-5, 8-10, 18-21 & 23

138. Claims 4-5, 8-10, 18-21 & 23 all depend from Claim 1. There are multiple limitations from Claim 1 that are not disclosed, taught or suggested by either *Gutierrez* or *Kahn.* Accordingly, none of the dependent claims are rendered obvious by the combination of *Gutierrez* and *Kahn,* nor by *Gutierrez* alone, which the Petitioner does not contend.

XII. CONCLUSION

139. All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. I further understand that willful false statements and the like are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code. I declare under penalty of perjury that the foregoing is true and correct.

Executed on July 11, 2025. By: ______________________________

Dr. Robert A. Durham

Dr. ROBERT A DURHAM, PhD, FIEEE

Resume
Specialization
Honors & Awards
Publications

Dr ROBERT A DURHAM, PhD, FIEEE

Robert A Durham is the Principal of D^2 Tech Solutions, a technology related firm concentrating on Mechanical and Electrical systems and energy conversions. He also serves as a Principal Scientist of THEWAY LABs, Tulsa, OK, an engineering and energy consulting firm that provides design and failure analysis of facilities and system installations.

Dr. Durham's work experience is broad and encompasses all areas of the energy industry. Dr. Durham spent 11 years with AEP/CSW, at the time the country's largest utility, in electrical engineering positions in the power generation and transmission planning departments. He then accepted a position as Manager of Electric Infrastructure for New Dominion, LLC., a major independent energy producer in Oklahoma. Dr. Durham then moved on to hold the position of Vice President of Engineering and Project Management for EDG Power Group, an Engineering Procurement and Construction company specializing in design and construction of small to medium size power generating facilities. Dr. Durham left EDG Power Group to accept his current positions. Dr. Durham has been accepted as an expert and offered testimony in several jurisdictions.

Dr. Durham's extensive client list includes the development of a broad spectrum of forensic, electrical and facilities projects for many companies. He has also taught University offered courses in electrical engineering review for board licensure. He has published five books, six magazine articles and over 40 other technical papers and articles. Dr. Durham's extensive work on standards and electrical systems has resulted in his elevation to Fellow of the IEEE, the highest grade of recognition in the electrical technology industry.

Dr. Durham received the B.S. in electrical engineering from the University of Tulsa in 1992 and the M.E. in Technology Management from The University of Tulsa in 1997. Tulsa, OK. In 2004, Dr. Durham received a PhD in Engineering Management from Kennedy Western University.

Degrees Earned

BSEE, with Honors, The University of Tulsa
Master of Engineering, The University of Tulsa
PhD , Kennedy Western University

Area of Specialization

lightning & grounding
failure analysis & forensic engineering
electrical power systems & safety
economics & management
petroleum & chemical industry
- drilling
- completion
- production
- transportation
- refining

electrical / mechanical energy conversion

Registration

Professional Engineer - Oklahoma
Professional Engineer – Texas
Professional Engineer – California
Professional Engineer – New Hampshire (Inactive)
Professional Engineer – Kansas
Professional Engineer – North Carolina (Inactive)
Professional Engineer – Missouri
Professional Engineer – Arkansas
Professional Engineer – Virginia (Inactive)
Professional Engineer – Illinois (Inactive)
Electrical Contractor - Oklahoma

Work History

D^2 Tech Solutions, Inc. Principal	2002 - 2025
THEWAY Corp. Principal Scientist	2004 - 2025

EDG Power Group, Inc. 2002 - 2004
Vice President Engineering & Project Management

New Dominion, LLC 2000 - 2002
Mgr Electric Infrastructure

Central & Southwest, Inc 1989 - 2000
Electrical Engineer

Professional Memberships

Fellow	Institute of Electrical and Electronic Engineers
Diplomate	American College of Forensic Examiners, International
Member	National Association of Fire Investigators
Voting Member	National Fire Protection Institute, Electrical Section
Executive Member	Petroleum and Chemical Industry Committee, IEEE
Diplomate, Past Board Member	American Board of Forensic Engineering and Technology
Member	IEEE Standards Association
Past Chair	Production Subcommittee, IEEE IAS/PCIC
CFC	American College of Forensic Examiners
Member	International Association of Arson Investigators
CFEI, CVFEI	National Association of Fire Investigators
Past Chair	Tulsa Section IEEE
Chair	IEEE RP1017.1 Working Group
Chair	IEEE RP1017.2 Working Group
Chair	IEEE RP1017.3 Working Group
Chair	IEEE RP1017.4 Working Group
Past Chair	IEEE PCIC Standards Subcommittee
Secretary	IEEE Petroleum and Chemical Industry Committee

Honors and Awards

Fellow of the IEEE

For contributions to submersible electrical equipment analysis and multi-point ground method in hazardous petroleum and chemical environments.

Honor Societies

Tau Beta Pi, national engineering honors
Eta Kappa Nu, national electrical engineering honors

Dr. Durham's publications have often successfully competed for outstanding paper awards from journals of the Institute of Electrical and Electronic Engineers (PCIC and IAS). This is an international competitive peer review and evaluation of papers that provide a significant contribution to the advancement and understanding of electrical applications.

IEEE Industry Applications Society, New Orleans, LA: Prize Article for "Data Quality and Grounding: Considerations in a Mixed Use Facility"

PCIC, Cincinnati, OK: Prize Paper for "Grounding and Bonding Conductors: Solid, Stranded, Bare or Insulated"

PCIC, New Orleans, LA: Prize paper for "Industrial Design Application for Power Distribution over Extra-Long Distances"

PCIC, Philadelphia, PA: Prize paper for "Paradigm Shifts and Impact on Engineers and Industry"

Transactions on Industry Applications, Orlando, FL: Prize Paper for "Lightning, Grounding, and Protection for Control Systems".

PCIC, Denver, CO: Prize Paper for "Grounding System Design for Isolated Locations and Plant Systems"

PCIC, St. Louis, MO: First place for "Lightning, Grounding, and Protection for Distributed Control and Communications Systems: A Retrofit".

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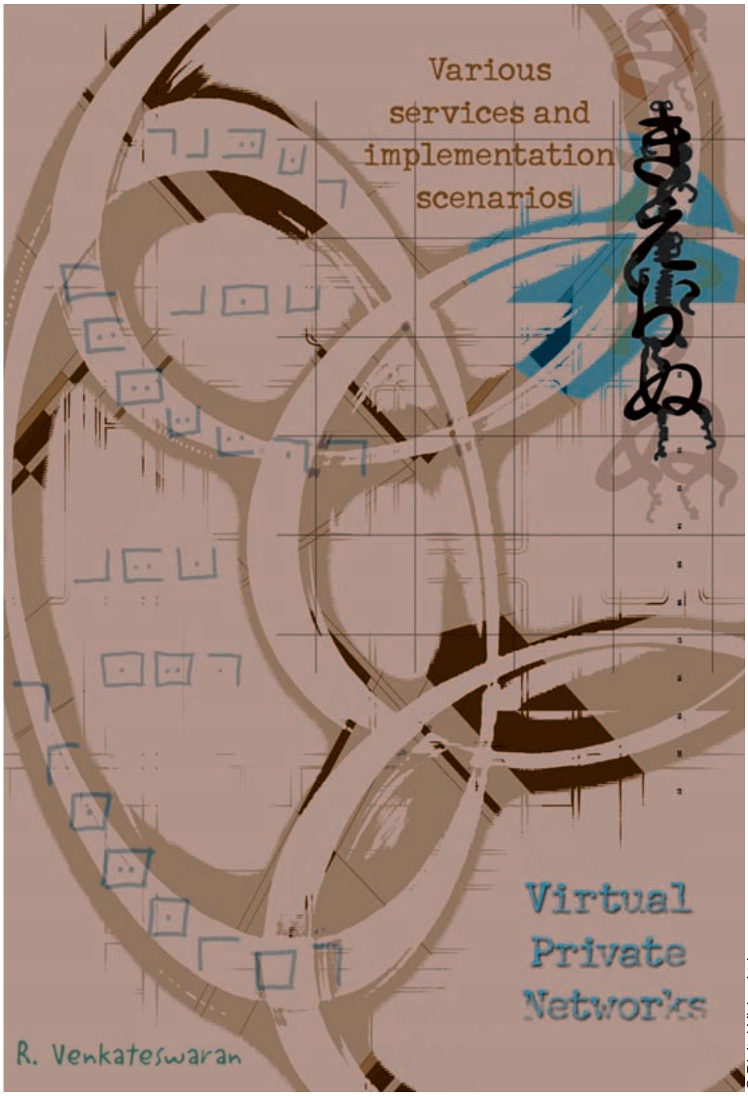
What is a Virtual Private Network (VPN)? First of all, a VPN is a *network*; that is, it provides inter-connectivity to exchange information among various entities that belong to the VPN. Secondly, it is *private*, that is, it has all the characteristics of a private network.

One might ask, "What characterizes a private network?" A private network supports a closed community of authorized users, allowing them to access various network-related services and resources. The traffic originating and terminating within a private network traverses only those nodes that belong to the private network. Further, there is traffic isolation. That is, the traffic corresponding to this private network does not affect nor is it affected by other traffic extraneous to the private network.



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The final characteristic of a VPN is that it is *virtual*. A virtual topology is built on an existing, shared physical network infrastructure. However, the virtual topology and the physical network are usually administered by different administrative bodies.

VPNs can be formally defined as *a communication environment constructed by controlled segmentation of a shared communications infrastructure to emulate the characteristics of a private network*. The access to the communication environment is controlled to permit interconnections for a defined community; even though, the underlying shared communications infrastructure provides services on a non-exclusive basis.

The following terminology will be used. The term *VPN* will refer to the private network of a company or enterprise. The term *shared network infrastructure* will be used to describe the underlying infrastructure on which the VPN is constructed. This can either be the public Internet or a network consisting of one or more service providers.

Motivations for VPNs

Why are VPNs so popular today? Traditional private networks facilitate connectivity among various network entities through a set of links, comprising of dedicated circuits (T1, T3 etc.). These are leased from public telecommunication carriers like MCI-Worldcom or Regional Bell Operating Companies (RBOCs) as well as privately installed wiring. [Note: T1 and T3 (used in the United States) have transmission rates of 1.544 and 44.736 Mbps, respectively.] The capacity of these links is available at all times, albeit fixed and inflexible. The traffic on these private networks belongs only to the enterprise or company deploying the network. Therefore, there is an assured level of performance associated with the network.

Such assurances come with a price. Traditional private networks are not cheap to plan and deploy. The costs of dedicated links are especially high when they involve international locations. The planning phase of such networks involves detailed estimates of the applications, their traffic patterns and their growth rates. The planning periods are long because of the work involved in calculating these estimates. Further, dedicated links take time to install. It is not unusual for telecommunication carriers to take about 60 to 90 days to install and activate a dedicated link.

Given the rapidly evolving network technologies and network applications, such a long waiting period can adversely affect a company's ability to react to quick changes in these areas. Network planners have to anticipate all possible scenarios that may arise due to these technological changes. The lack of network agility implies that a minor misreading of the market forces can have a magnified negative impact on the outcome of the company's businesses. Since accurately predicting the market is extremely difficult, a flexible Information Technology (IT) infrastructure that can quickly adapt is crucial.

Another recent trend is the mobility of today's workforce. Many companies are increasing employee's productivity by equipping them with portable computing facilities. Affordable laptops and various palm-based devices have made it easy for people to work without being physically present in their offices. Besides increased productivity, companies are encouraging telecommuting to reduce their investments in real estate. Also, it reduces traffic and pollution from automobiles.

To support the increase in home-offices, companies need to provide a reliable IT infrastructure so employees can access company information from remote locations. This has resulted in the deployment of large modem pools for employees to dial-in remotely. The

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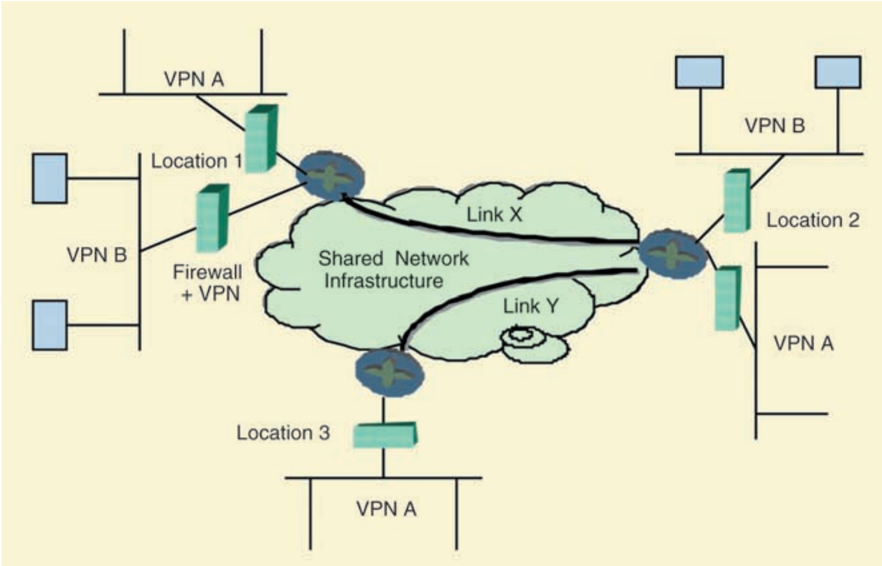

Fig. 1 LAN Interconnect VPN services

cost keeps increasing due to the complexity of managing and maintaining the large modem pools.

An additional cost with mobile users is the long-distance calls or toll-free numbers paid for by the company, which typically costs 5-7 cents per minute. For a US employee who puts in eight hours of work each week from remote locations, the dial-in cost itself adds up to $30 a week or about $130 (USD) a month. The costs are much higher if we consider international calling. Note that this cost does not include the cost associated with the modem pool itself. For companies with a large, mobile workforce, these expenses quickly add up to significant numbers.

What's more, the dial-in connection limits the remote user to a maximum access speed of 56 Kbps for analog modems and 128 Kbps for Integrated Services Digital Network (ISDN) modems. These limitations hamper the day-to-day activities that require high-speed access to the Intranet as available from a regular office. The home-office, therefore, becomes a poor substitute for the regular work environment.

Advent of high-speed access media like cable modems and Digital Subscriber Lines (DSLs), that are now becoming more available and affordable, can overcome the access speed limitations. But, the service providers offering high-speed accesses cannot have easy access to a company's Intranet due to firewall and security restrictions. Companies restrict access to prevent unauthorized intruders or "hackers" from stealing proprietary information. There is an urgent need for a reliable mechanism to authenticate valid users and restrict their accesses based on their access privileges.

E-commerce applications provide considerable advantages over traditional brick-and-mortar operations. Such applications are deployed around inventory management, supply-chain management, electronic data interchange (EDI) etc. For example, suppliers having electronic access to the company's inventory database helps the suppliers to schedule additional supplies based on the demand and current inventory levels. This helps to efficiently manage the inventory, eliminating the need to store large quantities of unused inventory.

But, in a traditional private network, this kind of special access is very difficult to incorporate because it is not easy to install dedicated links to all the suppliers. Further, this infrastructure is not flexible because any change in the supplier involves deinstalling dedicated links and installing new links to the new vendor. Quickly replacing a supplier result in enormous cost-savings, but an inflexible infrastructure makes it difficult to take advantage of these savings.

A Virtual Private Network (VPN) can help resolve many of the issues associated with today's private networks. As we will see, a VPN facilitates an agile IT infrastructure. Global VPNs enable connectivity to all locations anywhere in the world at a fraction of the cost of dedicated links. VPN services enable remote access to the Intranet at significantly lower cost, thus enabling support for a mobile workforce. Additionally, the VPN architecture supports a reliable authentication mechanism to provide easy access to the Intranet from anywhere using any available access media including analog modems, ISDN, cable modems, DSL and wireless.

Types of VPN services

There are primarily three types of VPN services:

1) Local Area Network (LAN) Interconnect VPN services,

2) Dial-up VPN services,

3) Extranet VPN services.

LAN Interconnect VPN. LAN Interconnect VPN services help to interconnect local area networks located at multiple geographic areas over the shared network infrastructure. Typically, this service is used to connect multiple geographic locations of a single company. Several small offices can be connected with their regional and main offices. This service provides a replacement for the expensive dedicated links.

A simple LAN interconnect example is shown in Fig. 1 . VPN A has sites in geographic locations 1, 2 and 3, while VPN B has sites in geographic locations 1 and 2. Both VPNs A and B are implemented on top of a shared network infrastructure. The advantage is the flexibility it offers.

For example, it is easy to increase the capacity of any of the links depending on the applications supported on the VPN. As applications change with time, the architecture can be adapted to meet the needs. Further, additional geographical sites can be connected to the VPN with very little effort.

These advantages come with a reduction in cost as well. Dedicated private lines are expensive. For example, in October 2000, a well-known telecommunications carrier quoted a price of $1300 a month for a dedicated 1.544 Mbps T1 link spanning a reasonable distance, plus a one-time installation charge of $3000. These costs are much higher if international sites are involved. On the other hand, using a shared infrastructure is cheap because of the economies of scale. The costs of the links are borne by the different VPNs that are supported on the infrastructure.

For example, in Fig. 1, the cost of

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virtual link X is borne by VPNs A and B. Suppose the shared link is used more by VPN A in the mornings, while VPN B uses more of the link in the evenings. If a dedicated link had been used for private network A, its capacity would have to be at least as much as to meet the demands of the morning traffic. This capacity is not needed in the evenings and therefore, remains unused and wasted. Company A has to pay for this unused capacity. Therefore, sharing the infrastructure helps companies A and B to reduce their individual costs. Keep in mind that even though the link is shared, the underlying shared network infrastructure retains the characteristics of a VPN by providing mechanisms to isolate and secure the traffic of each VPN.

Dial-up VPN services

The Dial-up VPN service supports mobile and telecommuting employees in accessing the company's Intranet from remote locations. A typical VPN is shown in Fig. 2. The remote employee (user) dials into the nearest Remote Access Server (RAS, the technical term for modem pool). This is typically a local Point-of-Presence (PoP) of an Internet Service Provider (ISP) or the shared network infrastructure.

In one dial-up VPN model, called the Layer 2 Tunneling Protocol (L2TP), the RAS automatically establishes a secure connection to a prespecified location inside the company's Intranet, usually through a firewall enhanced with VPN capabilities. Contingent upon successful authentication of the user, the secure connection enables the user to transparently connect to the Intranet. The L2TP model is also known as a "static" VPN connection and is usually aimed at home-offices and telecommuters who dial-in to a specific local RAS.

On the other hand, an alternate Point-to-Point Tunneling Protocol (PPTP) model focuses on the mobile user, who may dial-in to any local ISP. After connectivity has been established to the ISP, the user initiates a connection to any of the VPN servers located inside the company's Intranet. A remote authentication mechanism validates the user and establishes the access privileges. The successful establishment of the user-initiated connection enables the user to access the Intranet. In contrast to the L2TP model, the RAS does not participate in the establishment of the VPN connection. Therefore, no specific configuration of RAS is needed for the PPTP model. The PPTP model is also used for VPN connections based on high-speed access media like cable modems and DSL.

The dial-up VPN service results in considerable cost-savings to a company. It eliminates the need for managing large modem pools and uses the RASes that belongs to the local ISPs. There is also a significant reduction in long-distance charges because dialing in to the RAS is, in most cases, a local call. The monthly cost per user for a local ISP is about $20 for unlimited access. This cost is only 15% of the monthly long distance charges of the $130 per user that we had computed earlier. In addition, the dial-in VPN service takes advantage of high-speed access media, thus, eliminating some of the access limitations of the home-office.

Extranet VPN services

An extranet VPN service, shown in Fig. 3, combines the architecture of LAN Interconnect VPN services and dial-in VPN services. This infrastructure enables external vendors, suppliers and customers to access specific areas of the company's Intranet. The allowed specific area is denoted as the Demilitarized Zone (DMZ). When a

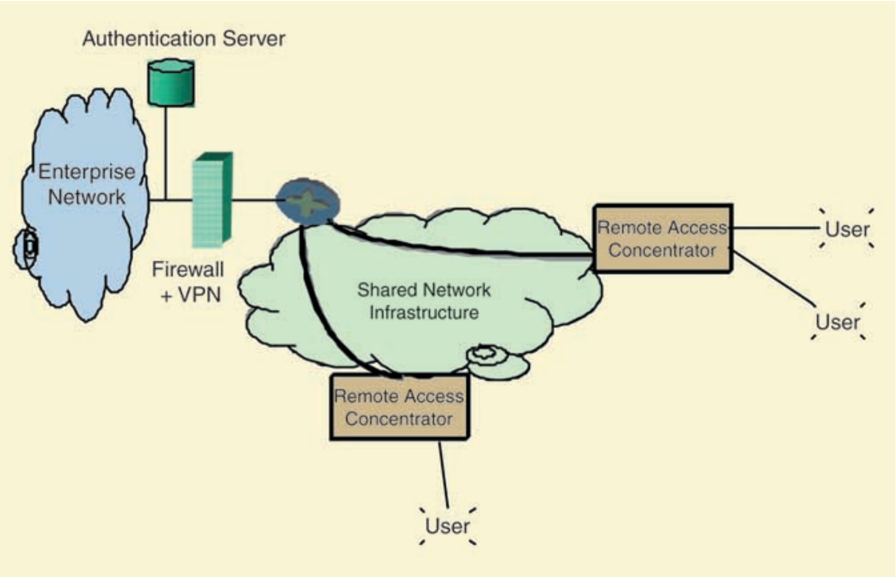

Fig. 2 Dial-up VPN services

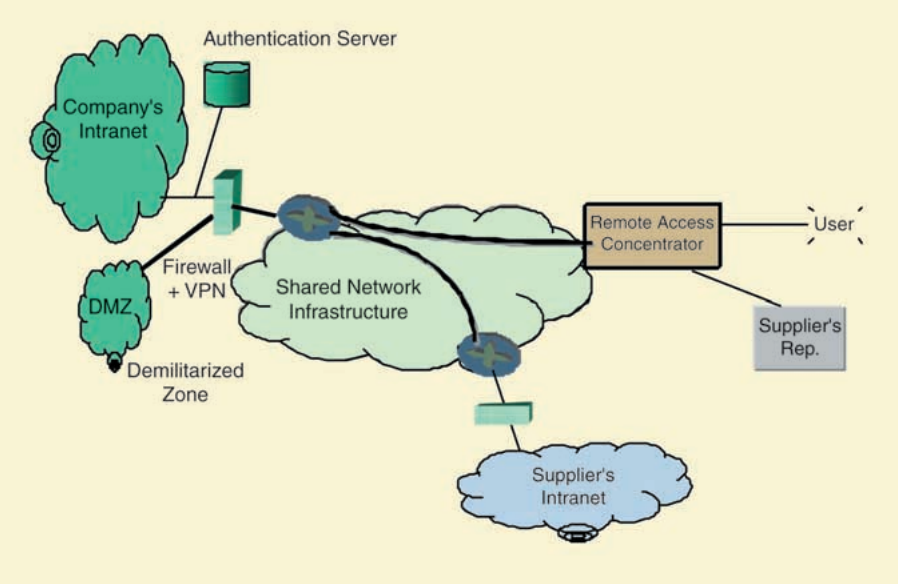

Fig. 3 Extranet VPN services

supplier's representative connects to the company's Intranet, either from the supplier's Intranet or dialing in remotely, the firewall and authentication mechanisms ensure that the connection is directed to the DMZ. A company employee (user), on the other hand, has full access to the company's Intranet.

The flexibility of the extranet services helps to provide connectivity to new external suppliers and customers within a short period of time. The fast communications facilitated by the extranet helps in several e-commerce areas including efficient inventory management and electronic data interchange (EDI). This provides significant savings in cost and the ability to effectively compete in the rapidly growing market.

VPN implementations

We have seen the advantages of VPN services. Now, we will focus on the capabilities of the underlying infrastructure that will help in implementing VPNs. Specifically, we will look at the various architectures for implementing VPNs. Typically, VPNs are implemented either at the network layer or at the link layer. Though application layer VPNs are also possible, we do not focus on such VPNs here.

Network layer VPNs

The network layer VPNs are usually based on Internet Protocol (IP) at the network layer. These VPNs can be implemented either by *tunneling* or by *network layer encryption*. A tunnel connects two points of a VPN across the shared network infrastructure. In the tunnel mode, the end-points of the tunnel are common nodes of the VPN and the shared network infrastructure.

Architecturally, the VPN is a collection of tunnels established over the shared network infrastructure. The network layer packets leaving a VPN node at one end of the tunnel are appended with an additional IP header whose destination address reflects the other end of the tunnel (remote VPN node). The packets are then routed based on this modified destination address through the shared network infrastructure to the other end of the tunnel. At this point, the additional IP header is stripped away to re-create the original packets reaching the remote VPN node at the other end of the tunnel.

Note that the original packets could be based on any Layer 3 protocol (like IP, AppleTalk or Novell's IPX) and still be carried across the shared infrastructure to the remote VPN node. Tunneling, therefore, helps to route multiple protocols across the shared network infrastructure. Further, the VPN and the shared network infrastructure may use different routing protocols without hindering the routing process. Typically, the network-layer protocol within the shared infrastructure is IP.

Another advantage of the tunneling mechanism is that the address mechanisms of the VPN and that of the shared infrastructure can be completely separated. Therefore, address overlaps across multiple VPNs can be easily handled without the need for Network Address Translation (NAT). Note, however, that when a VPN needs to connect to the external Internet, the NAT functionality is needed to translate the private VPN addresses to a set of global IP addresses.

A disadvantage of the tunnel architecture is that it is difficult to manage a large number of tunnels. Therefore, it does not scale well to a large number of VPN nodes. Further, the packets on the unencrypted tunnels can be eavesdropped by others attached to the shared network infrastructure. This tunnel is especially vulnerable at tunnel end-points where the extra headers are stripped away and the packets are visible in their original form. Since tunnels represent only the end-points and not the path taken to reach the other end of the tunnel, the paths taken across the shared network infrastructure may not be optimal. This can create serious performance problems for the VPN.

Network layer encryption provides a secure mechanism for implementing VPNs. The Internet Engineering Task Force (IETF) has standardized on a secure IP architecture, IPSec, which is a collection of protocols, authentication and encryption mechanisms. IPSec is an extension to the standard IP protocol. Parts deal with managing the encryption keys, key exchange protocol and protocol negotiations. These mechanisms can be used for encrypting other tunnels (like L2TP and PPTP) as well.

An IPSec packet has an IP header and, therefore, can be routed by current IP routers from one VPN node to another. Using an encryption algorithm and a set of encryption keys, the IPSec packet is created by encapsulating and encrypting the original IP packet. The encryption keys and the algorithm parameters are negotiated and exchanged between the two VPN nodes using the Internet Key Exchange (IKE) protocols (a part of IPSec protocol specifications) In addition, the IPSec packet may also have an authentication header, which authenticates the validity of the entire IPSec packet. This enables the receiver to verify that the packet has not been modified en route.

Link-layer VPNs

If the shared network infrastructure is based on a switched link-layer technology [like Frame Relay (FR) or Asynchronous Transfer Mode (ATM)], the VPNs implemented directly on these technologies are called Link-Layer VPNs. With advents in switch-routers and protocols like MultiProtocol Label Switching (MPLS) and MultiProtocol over ATM (MPOA), the line distinguishing the Network-layer VPNs and link-layer VPNs is getting hazy.

The links belonging to the VPNs are implemented as virtual circuits at the link-layer. The FR frames or ATM cells are switched across the shared network infrastructure from one node of the VPN to the other. The advantage of virtual circuits is that they are cheaper than dedicated links and they are very flexible. The virtual circuits also come with some Service Level Agreements (SLAs). They provide guarantees on the performance levels of the virtual circuits.

Link-layer VPNs are appropriate for LAN Interconnect VPN services. Link-layer VPNs are not ideally suited for dial-up VPN services because most ISPs provide connectivity through IP. Since dial-up VPN services offer the most cost reductions, IP-based network-layer VPNs look more attractive to IT managers than link-layer VPNs.

As with tunnels, there are scaling concerns when link-layer virtual circuits adopt a full-mesh architecture to connect each pair of VPN nodes. To help scale better, other kinds of architectures like partial meshes, hub-and-spoke may be considered. The trade-off with these architectures is that they may be sub-optimal.

VPN concerns

So, why aren't all companies rush-

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ing to deploy VPNs? A survey in "Telechoice VPN Market Report" (www.telechoice.com) showed that more than 25% of the 501 companies surveyed already have some form of VPNs in place. What about the remaining 75%? What are their concerns?

One major concern is security. Traditional private networks are very secure because all the links and the nodes the company deploying the networks the company owns. In a VPN, the data traverses links that are owned by service providers and are shared with other VPNs. Many companies are not comfortable with this idea that their packets could be eavesdropped by someone with malicious intent. The tunnel end-points are the most vulnerable locations on a tunnel-based VPN.

Advances in security features and the standardization of IPSec have reduced some of the security concerns. But, at the time of this writing, these standards are not fully mature . Though there are several IPSec-compliant vendor products , the standards are not mature enough today to guarantee interoperability across vendors. It is important for the protocols to mature and vendor products to become interoperable before we see a wider deployment of IPSec architectures.

Another cause for concern is the cost of deploying VPNs. Security features are not cheap. The encryption algorithms of IPSec are very compute-intensive. Therefore, use of encryption can have a negative impact on network performance. The various key management protocols associated with IPSec are also expensive to implement and manage. Given these facts, the hidden costs of deploying VPNs are not as attractive as the cost reductions advertised for VPNs.

Another issue of concern is the performance of the network and the quality of service (QoS). The public Internet is based on best-effort services. Therefore, no service level guarantees can be made if the public Internet is used as the shared network infrastructure for VPNs. A service provider implementing a VPN may be able to offer some service level agreements (SLAs), but these SLAs add up to the cost of deploying the VPN. Dedicated links must be established from the VPN service provider's network to the company's Intranet, which further increases the cost. The 85% cost reductions that are associated with VPNs will not hold true any longer.

There are different kinds of SLAs that service providers advertise. For example, some service providers advertise guarantees on network availability and end-to-end latency. Living up to these SLAs is a big challenge for the service providers. VPN network administrators must be able to demonstrate that the SLAs are indeed met at all times. On a shared network infrastructure, traffic separation, isolation and prioritization are necessary to assure that each VPN gets its requested share of the service.

Recent advances in IP router technology that enable class-based queuing, support for differentiated services and policy-based services have contributed to the success of meeting these demands. But, these advances are still in the preliminary stages. There is no widespread deployment of these technologies to test vendor interoperability and performance. Once again, designing networks with these capabilities come with added cost, which is reflected in the cost of deploying VPNs.

Using a VPN service provider has another drawback for VPNs because it limits the number of Points-of-Presence (PoPs). All service providers may not have PoPs at all the company locations and providing connectivity to PoPs can add to the cost of the VPN. Given these additional costs, it is no surprise that companies are waiting for the technology to mature before they jump on the bandwagon.

The future

VPN technology is still in its infancy. But the general belief is that in a couple of years VPNs will evolve and demonstrate all the advantages that they have promised. VPN will be a global technology linking geographic regions around the world. Adoption of standards in security and QoS technology will help vendors to minimize interoperability problems among their products. The service providers will then be able to offer and deliver precise SLAs. These SLAs will transcend multiple service provider networks.

As implementing and managing VPNs become increasingly complex, companies will favor outsourcing them, thereby, reducing their IT costs. At the same time, VPN service providers will be able to carve out a profit margin by offering different kinds of services.

Read more about it

• P. Ferguson and G. Huston, "What is a VPN," a whitepaper available from <http://www.clark.net/timw/vpn/Tech/vpn.pdf>.

• D. Fowler, *Virtual Private Networks: Making the Right Connection,* Morgan Kaufmann Publishers, San Francisco, California, 1999.

• Numerous VPN-related web sites. A good starting point with several links to relevant pages can be found at <http://kubarb.phsx.ukans.edu/~tbird/vpn.html>.

• Internet Engineering Task Force (IETF) publishes several documents: RFCs and Internet drafts: describing the various Internet standards. See <http://www.ietf.org>.

About the author

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Acronyms

ATM	Asynchronous Transfer Mode
DMZ	Demilitarized Zone
DSL	Digital Subscriber Lines
EDI	Electronic Data Interchange
FR	Frame Relay
IETF	Internet Engineering Task Force
IKE	Internet Key Exchange
IP	Internet Protocol
IPSec	IP Security
IPX	Internetwork Packet Exchange
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
IT	Information Technology
L2TP	Layer 2 Tunneling Protocol
LAN	Local Area Network
MPLS	MultiProtocol Label Switching
MPOA	MultiProtocol over ATM
NAT	Network Address Translation
PoP	Point of Presence
PPTP	Point-to-Point Tunneling Protocol
QoS	Quality of Service
RAS	Remote Access Server
RBOC	Regional Bell Operating Company
SLA	Service Level Agreement
VPN	Virtual Private Network

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REVIEW

The internet

R Al-Shahi, M Sadler, G Rees, D Bateman

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The growing use of email and the world wide web (WWW), by the public, academics, and clinicians—as well as the increasing availability of high quality information on the WWW—make a working knowledge of the internet important. Although this article aims to enhance readers' existing use of the internet and medical resources on the WWW, it is also intelligible to someone unfamiliar with the internet. A web browser is one of the central pieces of software in modern computing: it is a window on the WWW, file transfer protocol sites, networked newsgroups, and your own computer's files. Effective use of the internet for professional purposes requires an understanding of the best strategies to search the WWW and the mechanisms for ensuring secure data transfer, as well as a compendium of online resources including journals, textbooks, medical portals, and sites providing high quality patient information. This article summarises these resources, available to incorporate into your web browser as downloadable "Favorites" or "Bookmarks" from www.jnnp.com, where there are also freely accessible hypertext links to the recommended sites.

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"There are billions of neurons in our brains, but what are neurons? Just cells. The brain has no knowledge until connections are made between neurons. All that we know, all that we are, comes from the way our neurons are connected." Tim Berners-Lee, *Weaving the web*[1]

The internet—the largest network of computer networks—is the most important development in global communication since both the television and the telephone. The internet offers high speed communication and up to the second information in a cheap, user friendly medium. Access is potentially universal, notwithstanding the digital divide between developed and developing countries caused by a lack of hardware and telephone lines.[2] However, the internet is often maligned for being an unsafe, unstructured, uncontrollable occupational hazard with strange customs and jargon, which is time ineffective because of its low signal to noise ratio and potentially addictive nature (www.netaddiction.com).

The challenge now is not to get on line but to keep abreast of developments in internet technology and health information delivery to both professionals and patients, and to make the most effective use of them. This series of review articles and subsequent Neuronline fillers are intended to help with that process. Although the nature of the internet prevents this review from being comprehensive, the review aims to provide and build on a basic knowledge of the internet, with a focus on email and the world wide web (WWW), and with a slight bias towards content from the United Kingdom. If you are a newcomer to the internet you may wish to refer to table 1 and to supplement this article by reading a general guide to the internet[3] or existing review articles.[4–8] There are also guides to the internet specifically for doctors such as the Internet Medic section of the Resource Discovery Network (www.vts.rdn.ac.uk) or *Medicine and the internet*.[9]

SEARCH STRATEGY

This article is based on our own knowledge and a search of the following:

- Ovid Medline (1966 to 1 August 2001) for review articles in the English language in which the medical subject heading terms "Computer communication networks" and "internet" were the focus (http://biomed.niss.ac.uk);
- The WWW;
- The *British Medical Journal*'s medical informatics collected resource (www.bmj.com/collections).

ORIGINS OF THE INTERNET

The origins of the internet date back to the launch of the Russian satellite Sputnik in 1957.[10] The subsequent fear of the cold war becoming nuclear prompted the American government one year later to fund the Advanced Research Projects Agency (ARPA) to develop a means of electronic communication to secure American military technological superiority (www.isoc.org/internet/history/brief.shtml).

Two ways of broadening computer accessibility were time sharing—which enabled one computer to divide its processing capacity between different users connected to it simultaneously—and linking computers to form a network. The obstacle to developing networks was the incompatibility of their diverse operating systems. ARPA overcame this by developing a core network of identical interconnected computers, each known as an interface message processor, to which computers with diverse operating systems could connect to form the "ARPANET". Data were transmitted within this network, as they still are now, using an innovation called packet switching, in which messages are broken into equal packets each labelled with a header identifying its source, its destination, its position in the sequence, and whether the packet had become corrupted in

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Table 1 Glossary of abbreviations

Abbreviation	Name	Definition
ADSL	Asynchronous digital subscriber line	• A broadband telecommunication technology
ARPA	Advanced Research Projects Agency	• The central research and development organisation of the US Department of Defense
bps	Bits per second	• The standard rating of speed of data flow
CGI	Common gateway interface	• A means of generating dynamic content from a database on the WWW
DNS	Domain name system	• A means to translate host names into IP addresses
eTOC	Electronic table of contents	• An emailed table of contents of an online journal
FTP	File transfer protocol	• A means to exchange files between servers over a network
GIF	Graphics interchange format	• A compressed image format using minimal memory, best for block images
HTML	Hypertext markup language	• The principal programming language used to write pages on the WWW
HTTP	Hypertext transfer protocol	• The communication protocol used by servers to send files to browsers
ISDN	Integrated services digital network	• Digital telephone connections delivering broadband internet access
ISP	Internet service provider	• An intermediary company that connects a user to the internet
IP address	Internet protocol address	• One of a potential 4.2 billion 32 bit numbers in dotted decimal notation identifying a computer on the internet
JPEG	Joint Photographic Expert Group	• A compressed image format using minimal memory, best for shaded photographic images
LAN	Local area network	• A network serving a small geographical area, which permits faster transmission speeds. Versus MAN and WAN
MAN	Metropolitan area network	• A network in a geographical area larger than a LAN but smaller than a WAN
Modem	Modulator/demodulator	• Converts digital to analogue signals and back, to enable computers to communicate over a telephone line
MPEG	Moving Picture Expert Group	• The digital format encoding video images, displayed by dedicated software
NeLH	National electronic Library for Health	• A digital library for NHS staff in the UK
PDF	Portable document format	• A universal electronic document format that enables the style and layout of text and images to appear identical to the printed page
PGP	Pretty good privacy	• Freely available encryption software
POP	Point of presence	• Types of servers that convey email
RDF	Resource description framework	• An infrastructure that enables the exchange of metadata
SHTTP	Secure hypertext transfer protocol	• A communications protocol for financial exchanges over the internet
SMTP	Simple mail transfer protocol	• A communications protocol for regulating traffic between mail servers
SSL	Secure sockets layer	• A communications protocol for transmitting private documents via the internet
TCP/IP	Transmission control protocol/internet protocol	• The universal communication protocol used by the internet to transmit packets of data
URL	Uniform resource locator	• The unique address of a file accessible over the internet (fig 2)
W3C	World Wide Web Consortium	• A forum for information, commerce, communication, and collective understanding of the WWW
WAN	Wide area network	• A network in a geographical area larger than a LAN and a MAN
WWW	World wide web	• A global collection of interconnected servers, whose contents are viewed through a browser
XML	Extensible markup language	• A universal format for structured documents and data on the WWW

transmission. Interface message processors routed messages, reassembled them at their destination, and re-sent them if they were corrupted in transit. In such a decentralised, distributed network, bottlenecks could be avoided and even the loss of portions of the network would not prevent the flow of information. When ARPANET was launched at the end of 1969, there were four nodes, but by the end of 1972 there were 37 nodes across the United States. The network was extended across the Atlantic the following year.

As other networks of varying reliability were developed—predominantly in academic and military institutions—a unifying method of interconnecting them was needed. This was achieved by using gateways (called routers) between the separate networks that understood the protocols used by computers communicating across them and the now standard method of packet switching, called transmission control protocol/internet protocol (TCP/IP). IP handles the naming, addressing, and routing of packets, leaving TCP to split data, wrap them in virtual envelopes, reassemble them in the correct order at the destination host, and request retransmission of any packets that are lost or corrupted.

The internet has a hierarchical network structure linked through a backbone of supercomputers permanently joined by high speed optical cable connections, which traverse land and ocean. Metropolitan (MANs) and wide area networks (WANs) provide higher performance for larger geographical areas, being less dependent on the backbone. Local area networks (LANs) serve organisations such as the NHS in the United Kingdom.[11] LANs usually comprise their own private secure network (intranet), which can support any computer or device such as a printer (an ethernet), and which can be extended to other organisations over the internet using secure connections (extranet) (fig 1). Internet service providers (ISPs) link individual users to the internet through national point of presence (POP) networks in their vicinity.

ARCHITECTURE OF THE INTERNET

The terms "internet" (or "the net") and "world wide web" (or "the web") are often used interchangeably as if they were synonymous, without appreciating that the WWW is one of many services available on the internet. These other services include email, file transfer protocol (FTP), network news, Telnet (a means of accessing a remote, networked computer), and instant messaging (a means of detecting when others are connected to the internet and sending them a text message, approximating a real time conversation). Although telemedicine uses electronic communication technologies to deliver and support health care over long distances (http://tie2.telemed.org) the internet is not the main method used, so we will not deal with it further.

The world wide web

The WWW accounts for the majority of internet traffic. Tim Berners-Lee invented it at the European Centre for Nuclear Research (CERN) in 1989–90 as a means of sharing and cross referencing physics research in a consistent format.[1] While the underlying structure of the WWW has hardly changed since its invention, its function has developed enormously.

Browsers are software applications that create a user friendly virtual window on many of the internet services,

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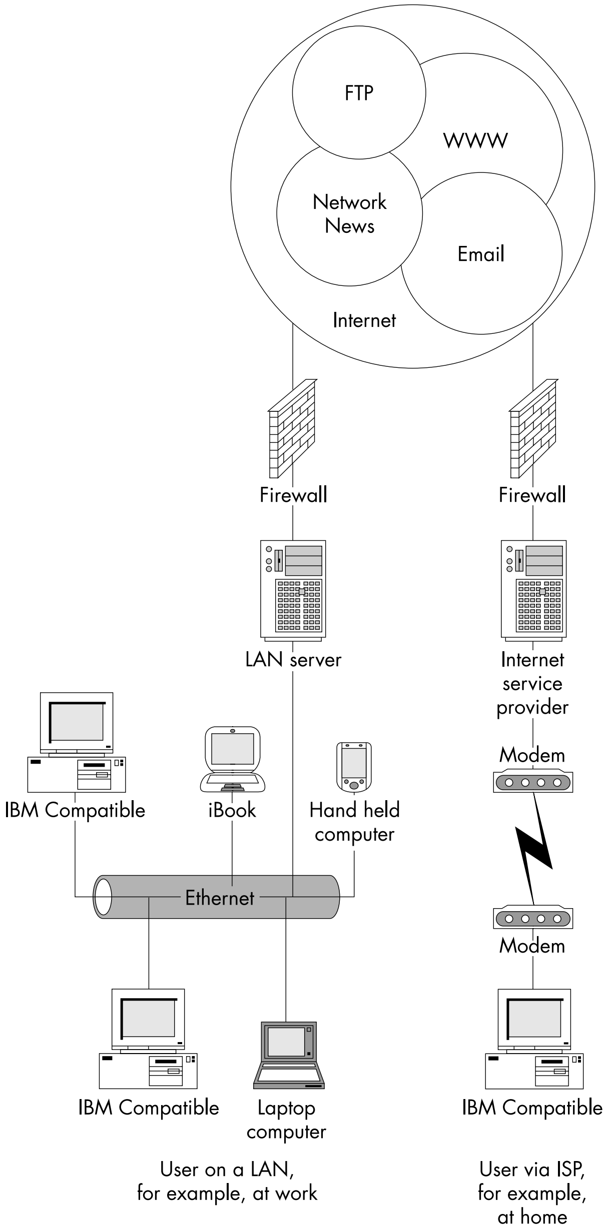

Figure 1 Simplified schema of the internet. FTP, file transfer protocol; ISP, internet service provider; LAN, local area network; WWW, world wide web.

behind which their different communication protocols are kept well hidden. The launch of the Mosaic browser in 1993 was the revolutionary development largely responsible for popularising the WWW; it could handle graphics as well as text, and navigation merely involved pointing and clicking with a mouse, rather than knowledge of the UNIX programming language. Browser technology is continually developing (www.browsers.com). The two main browsers are Microsoft Internet Explorer (www.microsoft.com/window/ie) and Netscape Navigator (http://browsers.netscape.com). The current browser series for use with recent operating systems is 6.x (the decimal after the series number indicates the particular version, denoting new features and fixed program bugs).

Pages on the WWW are held on servers (computers dedicated to sending, storing, or receiving information, usually permanently connected to the internet). The content and style of pages on the WWW were originally written exclusively in hypertext markup language (HTML), the pages were connected by hypertext links, and hypertext transfer protocol

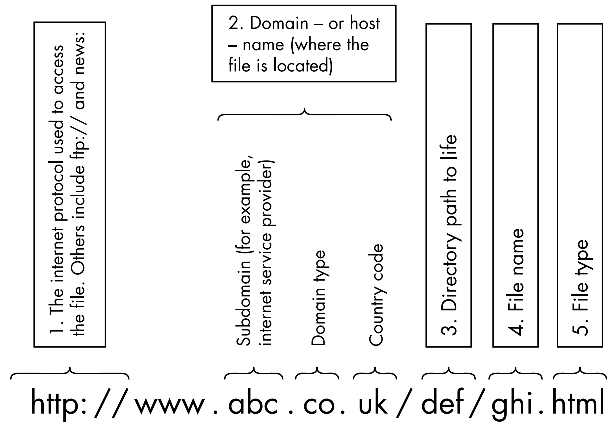

Figure 2 The components of a uniform resource locator (URL).

(HTTP) was used to transfer a web page written in HTML from server to browser. This WWW went public on 15 January 1991, and by November 1992 there were 26 WWW servers.

However, as the number of servers grew, unique dotted decimal IP addresses in the format 111.222.333.444, giving a possible 4.2 billion locations, were developed to identify each host server. Because humans prefer words and computers prefer numbers, invisible domain name servers now automatically translate exclusive case sensitive uniform resource locators (URLs)—developed to identify each page on the WWW (fig 2)—into the IP address of their host server. A client browser uses the path and file names in the URL to request the specific page from the server.

Text has been enhanced by a variety of media such as images (GIF and JPEG), video clips (MPEG), and sounds (WAV and MP3). A variety of programming languages have since enhanced the static content delivered by HTML with dynamic and interactive functions, such as searching databases and submitting data on WWW based forms. The World Wide Web Consortium (W3C) develops these technologies and their specifications, and issues guidelines on their use (www.w3.org). For example, JavaScript is a language embedded in HTML that is interpreted by a client's web browser and enables simple functions such as a change in a page's appearance in response to the location of the cursor. Another language, Java, is used to write small applications known as "applets", which are separately downloaded and executed by a web browser. The common gateway interface (CGI) defines how forms dependent on client side input (for example search facilities) communicate with servers running interactive applications such as databases. A structured, semantic WWW will be developed in the future using machine readable languages such as resource description framework (RDF) and extensible markup language (XML) to enable, for example, simple translation of web sites (http://babelfish.altavista.com).

To make the most of the WWW, there are several simple ways to enhance your browser use, which will make your online experience easier, quicker, and more controllable (table 2).

Electronic mail (email)

Email rivals post, facsimile, and telephone as the fastest, cheapest, most accessible, and most convenient way of transmitting text and files of any format between one or many networked computers.[7] The format of an email address is person@hostname, where the host name is the domain name of the internet host. Most email is accessed purely on the WWW (web mail) or through ISPs providing a mail server (POP mail) conveying emails that are read in an email viewing program. Popular web mail among doctors in the United

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Table 2 Enhance your use of a browser

Maintain software
- Use the latest version of your browser (determine which version you are using under the "Help" menu, "About")
- Update your browser monthly with the latest security patches
- Use the latest versions of free software to view multimedia content
  PaintShop Pro (www.jasc.com/products/psp)
  Adobe Acrobat Reader (www.adobe.com/products/acrobat)
  Shockwave (www.macromedia.com/shockwave)
  QuickTime (www.quicktime.com)
  RealPlayer (www.real.com)
- Install virus protection software and keep it up to date (www.symantec.com, www.nai.com, www.zonelabs.com)

Shorten the time you spend on line
- Use the world wide web before global use rises (between midnight and noon in Europe)
- Use mirror sites located in, or close to, your own country
- Download only text and omit multimedia content if the bandwidth of your connection is low*
- If you pay for the time you are connected to an internet service provider, download pages as you browse in separate windows (by holding the shift key down while you click on links) and read them later when you are off line

Minimise memory use
- Choose to install only the components of the browser that are essential to you (a full installation can consume up to 40 MB)
- Set your "History" folder to store web pages only for as long as you will need them*
- Optimise the size of your cache or "Temporary Internet Files" folder*

Customise your browser
- Set your browser's home page to a blank page (about:blank) or the web site you use the most*
- Organise your "Favorites" or "Bookmarks" into folders
- Set your preferred font type* and size (under "Text Size" on the "View" menu)
- Maximise the viewable area in your browser by removing the explorer bar and customising toolbars to show only the functions you use (as small icons)*
- Use the appropriate default programs for sending email, etc, from your browser*

Take short cuts
- When typing URLs, omit "http://", as your browser will automatically append it
- Use copy and paste functions to transfer URLs between documents and browser
- Right click with your mouse to save images, sounds, or videos from a web site to your hard drive
- If a web site cannot be found with the URL you have entered, try shortening it from the right hand end towards the domain name (fig 2) or use a search engine

*Change these under the "Tools" menu, "Internet Options" of Internet Explorer or the "Edit" menu, "Preferences" of Netscape Navigator. URL, uniform resource locator.

Kingdom registered with the General Medical Council is available through www.doctors.net.uk, which is also a portal (see below) for medical information. Many people have more than one email address, which can be aggregated by viewing programs as well as web mail (www.mail2web.com), provided you have your POP mail server name, username, and password for each account. Email can also unify other commonly used methods of communication such as fax and voice mail by converting these messages into an attachment (www.j2.com).

File transfer protocol
FTP is the most efficient method of transferring documents and software over the internet. A resource can be compiled on a remote server and a recipient can retrieve files from that resource at their leisure (rather than suffering a prolonged download time by email or waiting for a disc to arrive by post). Although there are programs dedicated to handling FTP (called FTP clients), modern web browsers are able to perform the same functions. Files are often compressed to economise on server space and speed transmission using freely available software (for example, www.winzip.com). While access is restricted to some FTP sites, anonymous FTP sites offer free files and software—called freeware and shareware—that can be searched using Archieplex (http://archie.emnet.co.uk).

Network news
There are close to 100 000 newsgroups, which are accessible from news servers (available on most networks and ISPs, although often in reduced numbers). Newsgroups can be viewed with a newsreader program but more often the multipurpose web browser is used. Newsgroups are indexed by http://groups.google.com. Newsgroups are similar to a bulletin board: discussion topics (called threads) are started in the relevant newsgroup and participants post opinions. There is considerable flexibility in the system, as observers choose which threads and messages to retrieve or censor, and which participants to censor, especially if they do not obey "netiquette" (see below). The lifetime of messages can be short to economise on the server space used to store them.

INTERNET ACCESS AND PERFORMANCE
The three fundamental requirements for internet access are a computer, a connection to the internet (via a LAN at work or an ISP at home), and web browser software. Attributes of the computer and your connection, in addition to the volume of internet use at the time, determine the speed and reliability of your access to the internet.[12]

The connection capacity is known as bandwidth and is rated in bits per second (bps). Dialup modems are the commonest means of accessing the internet from home; modems convert digital into analogue signals suitable for transmission through a telephone network and convert received analogue signals back into digital data. Modern telephone modems are rated at 56 000 bps (or 56 Kbps), and with eight bits in a byte (each byte determining one character), they can transmit seven kilobytes—or 7000 characters—per second, although 32–40 Kbps is the best seen in practice. Faster access, continuous connection, and simultaneous telephone access are provided by pure digital services offering broader bandwidth (broadband), which also eliminate the ~30 second dialup modem connection time. Integrated services digital network (ISDN) and asynchronous digital subscriber line (ADSL) use telephone lines with modified hardware to send digital signals—without the need for analogue transformation—at capacities of up to 128 Kbps and 6 Mbps, respectively. Cable and satellite also offer broadband telecommunications of 1–10 Mbps. These and wireless networks (such as www.bluetooth.com) are the emerging telecommunications for the internet, but they are costly for now, some

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Table 3 Useful web sites by category

Site	URL	Description
Searching the internet		
Google	www.google.com	• One of the largest search engines
Copernic	www.copernic.com	• A free search agent that searches multiple directories and search engines
Archieplex	http://archie.emnet.co.uk	• FTP search agent
Google newsgroups	http://groups.google.com	• Newsgroup indexing service
Medical portals		
National electronic Library for Health	www.nelh.nhs.uk	• A partnership with NHS libraries to develop a digital library for NHS staff, patients, and the public
TRIP database	www.tripdatabase.com	• A free searchable database of over 55 sources of high quality, evidence based information and online journals
Netting the Evidence	www.nettingtheevidence.org.uk	• A comprehensive resource for evidence based practice
BIOME	http://biome.ac.uk	• A searchable catalogue of quality internet health and biomedical resources (incorporating Organising Medical Networked Information (OMNI))
Doctors.net	www.doctors.net.uk	• A free news, discussion, literature, jobs, and email service for doctors in the United Kingdom
Medical conferences	www.medicalconferences.com	• An interactive free compendium of worldwide medical conferences
Journals		
PubMed	www.ncbi.nlm.nih.gov/entrez	• Provides a searchable version of Medline with links to online journals, integrated with other protein, nucleotide, and genome databases
PubMed Central	http://pubmedcentral.nih.gov	• A digital archive of life sciences journal literature
Free Medical Journals	www.freemedicaljournals.com	• A portal dedicated to indexing and promoting free access to medical journals on the WWW
Zetoc	http://zetoc.mimas.ac.uk	• The British Library's email service for all their journals' latest tables of contents
BioMed Central	www.biomedcentral.com	• An independent publishing house committed to providing immediate free access to peer reviewed biomedical research
Textbooks		
Free Books 4 Doctors	www.freebooks4doctors.com	• A portal dedicated to free access to medical books on the WWW
eMedicine	www.emedicine.com	• A free, WWW only textbook of medicine
Research resources		
Current Controlled Trials	www.controlled-trials.com	• Promotes the availability and exchange of information about ongoing randomised controlled trials in all areas of health care
BioMedNet	www.bmn.com	• A portal for biological medical researchers
Wisdom	http://wisdom.wellcome.ac.uk	• A comprehensive United Kingdom research funding database
For patients		
Patient UK	www.patient.co.uk	• A directory of United Kingdom health and disease related web sites for patients
Healthsites	www.healthsites.co.uk	• A portal for health related information, with sections for patients or doctors
MedicDirect	www.medicdirect.co.uk	• Portal for health related information for both patients and doctors
QuackWatch	www.quackwatch.com	• Surveillance of bogus health web sites
Dictionaries		
Online medical dictionary	http://cancerweb.ncl.ac.uk/omd	• A searchable dictionary
Who Named It?	www.whonamedit.com	• Dictionary of eponyms

All web sites accessed 26 July 2002. FTP, file transfer protocol; URL, uniform resource locator; WWW, world wide web. These URLs are dowloadable as a Bookmarks/Favorites file from the *JNNP* web site (www.jnnp.com).

require bandwidth to be shared with one's neighbours, and access is limited in some countries and in rural areas.

If you connect to the internet via an ISP, performance will also be determined, in part, by which internet backbone(s) the ISP connects to, what connection speed they support, and whether there is a local POP server. Moreover, the greater the bandwidth between your computer and your ISP's server, the more the speed of internet access is limited by the speed of the connection between your ISP's server and the other servers making up the backbone of the internet. All ISPs should provide POP email addresses and some also provide a few megabytes of server space where you can post a web site. Attention should be paid to whether there is a charge for setup and the expense of calls for customer support and to dialup (do they charge local rates only and are off peak discounts offered?). For example, in the United Kingdom free access is possible because local calls are metered, and an ISP would gain revenue from your telephone bill and often astronomical helpline rates. Web sites have grown up to specifically inform consumers about the relative merits of the wide variety of ISPs (for example, www.ispreview.co.uk).

Once you've established a satisfactory connection to the internet, the resources available can revolutionise your life, if you know where to find them and how to make the most of your online experience. In the following sections we discuss issues likely to concern the *JNNP* readership, we describe ways of enhancing the use of the WWW and email, and we provide a directory of web sites of general medical interest (table 3).

MEDICAL CONCERNS ABOUT THE INTERNET

The quantity of medical information on the internet and the escalation of its use by both providers and consumers of health care have led to specialists in "cybermedicine" studying its application, impact, and evaluation.[13] Two of their greatest concerns are security and the quality of information, for both patients and doctors.

Security

Security was not a major concern in the original design of the internet. The communications protocols underlying the WWW (HTTP) and email (simple mail transfer protocol (SMTP)) leave communication open to interception by traversing many different computers, which has led to the use of encryption (in which a message is encoded by the sender and decoded by the receiver). Because the online community sees the main methods of encryption as potentially vulnerable to covert surveillance by government agencies who know how they work, other security measures have developed.

The transmission of health related data in particular should be confidential, unmodified, authenticated, and impossible to

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renounce.[14] The responsibility for this rests with administrators running networks and servers as much as it rests with individual users. These standards pose a challenge for electronic patient records projects (although they avoid the drawbacks of paper based records being unavailable, incomplete, and insecure)[15] but electronic records do require coding systems, standard communication protocols, and secure electronic protection, for example, using smart cards.[16 17] While a secure WAN called NHSnet (www.nhsia.nhs.uk/nhsnet) is being developed in the United Kingdom with expanding capabilities in this area, one web site provides dedicated electronic medical records for a fee (www.personalmd.com).

Theses issues aside, to maximise the security of communication over the internet, there are a few key precautionary measures to take, depending on the medium.

The world wide web

The most widely used encryption algorithm is 128 bit key RSA (named after the initials of its inventors), which relies on mathematical properties of large prime numbers. RSA is used by Netscape Communications' reference standard secure sockets layer (SSL) protocol and the secure hypertext transfer protocol (SHTTP) developed by CommerceNet. A URL that begins with "https://" means that the server is secure, indicated by a closed padlock image on the status bar of your browser. It is your responsibility, however, to ensure that SSL is activated in the Options/Properties menu of your browser; the server checks only that you enter the SSL port and not whether your browser is actually using SSL.

Other security measures you can take for browsers are using the current version of your browser (which would be compatible with the latest security software and have known security risks protected), setting a medium to high level of security (in Tools/Internet Options), disabling AutoComplete functions for forms (to stop your browser storing your passwords), and disabling embedded client side programming languages (such as Java), which would otherwise expose your browser to threats from applets that can exploit the data on your computer.

Lastly, "cookies" deserve special mention; they are small files placed on your computer by a web site host server (www.cookiecentral.com). Because some IP addresses are not static but are dynamically allocated (for example, when you dial in to an ISP, addresses are allocated from its limited pool of IP addresses), cookies were developed to enable their web site of origin to recognise a specific returning user. By aiding recognition, cookies speed up logging into password protected zones and allow personalisation of WWW content, but they also help web site developers to assess their site's traffic and monitor viewing habits. Clearly, using cookies is unwise on shared computers but it is a matter of personal preference as to who accepts them and whether you enable the cookie alerting mechanism in your browser. The only cost of greater security, of course, is that you will be unable to benefit from the enhancements offered by cookies and Java applets.

Email

Although emails can potentially be intercepted, the sheer volume of internet traffic makes this unlikely, unless your account is specifically surveyed, for example, by administrators with access to your incoming mail server. In countries where email monitoring by employers is legal, interception cannot be prevented. However, email can be rendered decipherable to only its intended recipients by using public-private key encryption methods. One example is a new freely downloadable format called pretty good privacy (PGP), available from www.pgpi.org. The legality of using encrypted email for the transmission of patient identifiable data is, to our knowledge, as yet untested in the United Kingdom.

The other main email security issue is the inadvertent receipt of malicious programs that are designed to extract themselves and spread, called viruses, Trojan horses, worms, or blended threats, which are combinations of them. When a user performs an action (such as opening an email attachment), a virus may infect other programs or hidden system files, a worm replicates itself over a network (for example, by sending itself to all contacts in an email address book), and a Trojan horse opens a port to the internet to allow unauthorised access to your computer or network. In the main, these threats can be avoided by not opening email from suspicious senders or suspicious attachments from known contacts. Additional protection can be provided by installing a personal or network firewall, which is software or hardware, or a combination of both, that protects incoming (and outgoing) traffic and ensures that only authorised ports are visible to the internet (www.zonelabs.com). The other essential measure is to install virus protection software and keep it up to date (www.symantec.com or www.nai.com).

Finally, once you have an email address you may receive unsolicited junk mail ("spam") from advertisers, who use sophisticated software to scavenge your email address from sources on the internet. This likelihood is increased if you sign up to public newsgroups, discussion forums, or email directories. A prudent strategy is to have at least two email addresses, one of which is solely for personal mail.

Information quality

Freedom to publish on the WWW is responsible for its best and worst characteristics: valuable innovation diluted by extraneous information. Although high quality information is promoted by various organisations such as the Health for Help Trust (www.hfht.org), it seems that high quality information about common conditions is often difficult to find, incomplete, and inaccurate and uses language that is too complicated.[18]

Because poor quality information about health is at best misleading, and at worst harmful, critical appraisal is necessary, but who should perform it? Patients would find an instrument to assess each web site they visit helpful. Although none of these assessment tools is validated,[19] the following common sense quality criteria seem indisputable[20]: accurate, up to date, and comprehensive content; attributable and authoritative authorship; disclosure of competing interests; clear design; user support; and an assurance that personal health information submitted by users is kept confidential. For now, DISCERN (www.discern.org.uk) and the Health Information Quality Assessment Tool (http://hitiweb.mitretek.org/iq) are the best tools available for patients[21 22] but how much they are used is unknown. Alternatively, patients can consult directories or portals that act as trusted third parties and filter content for the user (table 3).

Internet commentators are divided as to whether quality filters or standards and evaluation instruments should exist at all.[23] If instruments are to be used, there are demands for evidence of their effectiveness.[19] Future solutions include software that searches a web site's invisible metadata (assigned by its author) and a rating service for information about the web site's content and context.[24]

WORLD WIDE WEB RESOURCES

While web sites designed to find what you want on the WWW inevitably reflect the information available, their ability to recognise which web site is most relevant to your requirements has become excellent.

Search engines, subject directories, and search agents

The web sites that help you find your way around the WWW are freely accessible. They may be search engines (for example, www.google.com), which automatically scour the WWW itself for sites of relevance, directories of sites compiled and reviewed by the authors of the directory (for

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example, http://dmoz.org), hybrids of the two (for example, www.altavista.com), or search agents (for example, www.copernic.com).

Search engines are valuable for their sensitivity, whereas directories have a higher specificity.[25] Up to date information on the relative merits of the various engines is available from a site called Search Engine Watch (www.searchenginewatch.com). At the time of going to press Google (www.google.com) and AllTheWeb (www.alltheweb.com) vie for the largest and most comprehensive index.

Subject directories—also called gateways or portals—are usually indexed in a hierarchical file structure and are rated by the people who compile them, so local information is best found on the regional version of the directory (for example, http://uk.yahoo.com, rather than www.yahoo.com). Although directories have a health category, the highest quality medical information is to be found on specialist portals (below).

Crucial to finding the web site closest to your requirements is using search terms most specific to your needs, yet sensitive enough not to miss anything useful. Most important, read the About section of the search engine or directory you choose to use. Engines can search for particular types of file (for example, web pages, sound files, and graphics), in certain languages, using suggested keywords and Boolean commands (to incorporate multiple terms, for example, or to exclude others).

Undoubtedly the most powerful method of finding the information you want is to use a search agent, such as Copernic (www.copernic.com), which automatically searches multiple search engines and directories with your search terms, removes duplicates, and compiles and ranks the results.

Medical portals

Search engines are best used with very specific search terms but they tend to return an overwhelming quantity of health information of generally poor quality with a general term, such as the name of a disease. The accessibility, format, and functionality of the WWW enable medical portals to come into their own in providing indexed, comprehensive databases of high quality information and they enable journals and even textbooks to be reproduced on line.[26 27]

However, there is a profusion of medical portals offering these collated resources to doctors, patients, or both (generally from North America with URLs beginning with www.med or www.MD), sometimes requiring a subscription. Because of the fierce competition in this area, the portals are subsuming each other (for example, www.medscape.com was recently acquired by www.webmd.com). Your country of origin will partly influence your choice of portal; HealthWeb (http://healthweb.org) and BIOME (http://biome.ac.uk) are high quality resources in North America and the United Kingdom, respectively. The "list of lists"—the Hardin Meta Directory (www.lib.uiowa.edu/hardin/md)—is inevitably compendious but has a lower signal to noise ratio. Some portals, such as Doctors.net (www.doctors.net.uk), go even further to try to foster an online community by offering other services such as discussion forums, a searchable database of colleagues, a classified section, server space for document storage, and e-commerce.

In the United Kingdom, the National electronic Library for Health (NeLH) (www.nelh.nhs.uk) is a promising initiative aimed at delivering high quality information to improve patient care in the NHS.[28] The NeLH is a gateway for staff in the NHS to access a variety of resources, primarily concerning evidence based medicine (available in even more detail from www.nettingtheevidence.org.uk). Whereas only the abstracts of reviews in the Cochrane Library are available to anyone (www.update-software.com/cochrane/abstract.htm), the NeLH provides the entire contents of the Cochrane Library. Similarly, access to the entire contents of *Clinical Evidence* (www.evidence.org) and Evidence Based On Call (www.eboncall.co.uk) are available through the NeLH. There are links to PubMed (www.ncbi.nlm.nih.gov/entrez) and a comprehensive database of guidelines from among other sources the Scottish Intercollegiate Guidelines Network (www.sign.ac.uk), the National Institute for Clinical Excellence (www.nice.org.uk), and the National Guideline Clearing House (www.guideline.gov), based in the United States. If you do not have access to the NeLH, the TRIP database (www.tripdatabase.com) provides a free search of the main evidence based resources, peer reviewed journals, guidelines, and e-textbooks on the WWW.

Journals

Internet idealists see the WWW as the most revolutionary development in publishing since the printing press. Online repositories for articles, such as BioMed Central (www.biomedcentral.com) and PubMed Central (http://pubmedcentral.nih.gov), have embraced the ideal of free access for all to the medical literature.[29] PubMed Central provides free access to some print journals already offering their entire contents on line (for example, www.bmj.com), in addition to the purely electronic journals in BioMed Central (for example, *BMC Neurology*). Articles in these reservoirs of knowledge benefit from being indexed in PubMed, published the moment they are accepted, and their copyright is not transferred to the publisher. The site www.freemedicaljournals.com provides a comprehensive list of medical journals, which are free either at the point of publication or after a delay (for example, *JNNP* has been published on line since 15 March 1999[30] and articles are free one year after print publication).

There are several other advantages of online publication, such as the speedy dissemination of netprints or preprints (research before, during, or after review by other agencies),[31] WWW based supplements to print articles that are likely to improve the quality of reporting,[32] and preprint servers that may help prevent publication bias.[33] Hypertext links between reference lists from an article in one online journal and the original article in another and from portals directly to the online journal obviate the need for laborious journeys to the library. Online article submission (now available for *JNNP*) enables faster peer review and a seamless transition of an article in electronic format from submission to publication, with communication by email. Article citations can be downloaded to reference management software or downloaded as portable document format (PDF) files with Adobe Acrobat (www.adobe.com/products/acrobat) for printing, indistinguishable from the paper version of the article. Moreover, because a browser's country of origin is recognisable from its IP address, free full text access can be delivered to resource poor countries.[34]

Lastly, journals' emailed tables of contents (eTOCs) and automatic alerts about articles on particular topics or by particular authors can result in a more time effective way of keeping up to date. Signing up for an eTOC is usually done through an online journal's web site, a subscription to the journal is not usually required, and removing oneself from the list is as easy as signing up. An excellent eTOC service, offered for any journal received by the British Library (whether or not the journal provides an eTOC of its own), is available from Zetoc (http://zetoc.mimas.ac.uk), which can be accessed freely via the NeLH.

Despite the myriad advantages, sceptics view online journals as a threat to the "integrity of the scholarly record of science"[16] and resent the loss of the aesthetic appeal of a paper journal. Publishing houses fear a greater burden for peer review with easier article submission, loss of copyright, and lower revenue from print subscriptions, which are only slightly offset by online subscriptions and pay-per-article fees,

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themselves jeopardised by unlegislated information sharing technology (such as Napster and Gnutella). Given the spectrum of solutions adopted by medical journals to the pressure to provide access on line and the lack of knowledge about its impact, an e-journal user study is underway (http://ejust.stanford.edu).

e-Textbooks

FreeBooks4Doctors (www.freebooks4doctors.com) is a portal dedicated to indexing textbooks that are freely available on the WWW, whether they are purely electronic or not. At the forefront, eMedicine (www.emedicine.com) is a comprehensive, entirely WWW based e-textbook and portal, requiring only registration (and not a paid subscription). Despite the appearance of sponsors and advertising on the web site, authors are independent of the pharmaceutical industry. UpToDate (www.uptodate.com) is an independent e-textbook but it requires a subscription. The vast majority of printed medical textbooks with an online version require a subscription, such as Harrison's Online (www.harrisonsonline.com), which is an expanded, continually updated, cross referenced version of the 15th edition of *Harrison's principles of internal medicine*. Other textbooks, such as the *Oxford textbook of medicine*, are available for purchase only as a CD ROM.

Research

In addition to the medical portals that compile evidence based resources and journals for use in routine practice, which are equally applicable to the needs of researchers, national and international repositories of research activity are of particular value. Registries of ongoing and completed studies are important to prevent unnecessary duplication and publication bias, and can provide paradigms for other areas where research is needed. For example, the National Research Register compiles data about research activity in the United Kingdom (www.update-software.com/National), while Current Controlled Trials (www.controlled-trials.com) and Centerwatch (www.centerwatch.com) collate information about randomised controlled trials in particular. Funding resources are even more specific to your country of origin, but the Wisdom database run by the Wellcome Trust is the best starting point in the United Kingdom (http://wisdom.wellcome.ac.uk).

Patients

Because internet access and usage are rising dramatically and health is one of the main categories of information sought, the provision of high quality patient information is essential. Although some have doubted the importance of this phenomenon,[35] a recent survey found that a quarter of patients with home access to the internet used medical web sites before consultation at a neurology clinic, and this information was inappropriate in 60% of cases.[36] Because misinformation may be harmful due to incorrect self diagnosis, inappropriate treatment discontinuation, or self medication and because of the potential of the internet to encourage suicide, organisations exist to monitor health fraud on the WWW (www.quackwatch.com).

The Health On the Net Foundation (www.hon.ch) is a not for profit organisation to guide patients (and medical practitioners) to useful and reliable online health and medical information, guided by their established code of conduct. Possibly the best web sites for providing patients with information about the whole range of medical conditions are www.patient.co.uk, www.healthsites.co.uk, and www.medicdirect.co.uk in the United Kingdom and www.healthfinder.gov in the United States.

EMAIL

Professional use

Email is the most effective way to keep up to date with journals' eTOCs, which are often sent before print publication. Many professional associations' web sites offer similar email alert services to maintain awareness about meetings and newsletters and to provide a simple way to register and submit abstracts for conferences. Email is also being used by journals to speed up the process of peer review using WWW based systems.

For those less daunted by large scale communication, mailing lists, newsgroups, bulletin boards, web forums, and the notorious chat rooms offer online communities in which peers can exchange news, opinions, and comment. Mailing lists are usually administered by a host institution and use software such as Listserv (www.lsoft.com) to circulate emailed contributions to a discussion on a particular topic. Join a list by simply sending an email to the administrative address (the membership of some lists is vetted). Anonymity is maintained unless you wish to contribute and content is usually moderated. A good starting point would be the Medicine and Health category at www.jiscmail.ac.uk. Newsgroups (such as misc.health and sci.med, available via http://groups.google.com), bulletin boards, and web forums (www.theabn.org/training) offer a similar, but web based, means of communication that does not clog your email inbox.

The online doctor-patient relationship

As public use of email expands there is considerable potential for the doctor-patient relationship to be electronic. While such email correspondence is not critical to medical practice and unlikely to be a substitute for at least an initial consultation in person, there are conceivable benefits and predictable drawbacks, which still require further research.[37]

As an asynchronous medium, email enables correspondents to respond at their own convenience in a time effective manner, averaging four minutes per email in one study.[38] Email avoids the need to return missed telephone calls. Email is also likely to be cost effective by minimising outpatient attendances, but this has not been evaluated. Email is said to be less intimidating for patients than a face to face encounter and may enable them to discuss sensitive issues more freely, while it enables the doctor to provide a considered, documented response. Of course, email misses the subtleties of communication in person.[38]

There are drawbacks to doctor-patient email but they should be viewed in the context of the medical profession's initial reluctance to adopt the telephone as a means of communication.[39] Doctors are sceptical mainly about the workload that email may generate; time spent on this may be managed by having an email account dedicated to patient correspondence. There are potential legal liability issues and strong arguments for privacy and confidentiality, which require encrypted communication. Furthermore, if email communication about health care becomes commonplace, patients who are not on line may become disenfranchised.

The American Medical Informatics Association has proposed contractual guidelines for the doctor-patient online interaction.[40] We have summarised these guidelines in table 4 but they apply only to an already established doctor-patient relationship. They do not address unsolicited email,[41] nor what doctors' conduct should be in mailing lists, bulletin boards, chat rooms, and newsgroups involving patients. In all circumstances, it is wise to heed the informal code of conduct, known as netiquette (www.albion.com/netiquette), which is largely a reminder to interact as you would in other media but also to respect others' privacy and bandwidth.

INTERNET FUTURES

The internet will become omnipresent and so transparent that it will be taken for granted as much as electricity is in the developed world. The future aims of internet technology are embodied by the goals of the W3C: to enable universal access, establish a "semantic web" with meaning using machine

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Table 4 Guidelines for email exchange between doctor and patient

Joint responsibilities
- Establish what the purpose(s) of email exchanges will be
- Establish the turnaround time expected of both doctor and patient (possibly depending on context)
- Avoid anger, sarcasm, criticism, and libellous references to third parties
- Use encryption to protect the privacy of email content

The doctor's responsibilities
- Ensure the patient is aware of security and confidentiality issues
- Obtain the patient's informed consent for the use of email, specifying your terms
- Protect access to your email inbox and your screensaver with passwords
- Do not distribute a patient's email to third parties, unless they have agreed to it
- Use an electronic signature and a header to warn about privacy issues
- Set up an automatic reply to confirm receipt of patient's email
- File printouts of all email correspondence in the medical record
- Back up your email folders weekly
- Maintain an address book of patients who can be (anonymously) mass mailed in the event of technical problems

The patient's responsibilities
- Categorise the email in its subject heading
- Use identifying information (such as a hospital number) in the body of the email
- Use an electronic signature
- Acknowledge receipt of doctor's reply

Adapted from the American Medical Informatics Association.[40]

readable languages, establish enhanced security, avoid software incompatibility, ensure that technologies are evolvable, preserve the distributed decentralised nature of the internet, and encourage more interactivity and richer multimedia.

The most immediate challenge for the next generation internet (www.ngi.gov) is to support increasing demand for both access and greater speed. In the next few years advances in fibre optic technology will hugely increase the capacity of the backbones as they become more extensive, perhaps even to the interplanetary internet (www.ipnsig.org). Dialup modem access will soon become a thing of the past as "always on" broader bandwidth alternatives (such as cable, satellite, digital subscriber line, and T1 and T3 networks) pervade the developed world. Wireless data services in the 1–2 Mbps range (www.wireless.com) may obviate the need for fixed cabling. The 4.2 billion potential IP addresses are fast running out, heralding the next addressing standard, Ipv6, which will allow a staggering 6×10^{23} internet addresses per *square metre* of the Earth's surface, with built in security and automatic address allocation.

In medicine, it is likely that additional change will be partly driven by patients changing from passive recipients of health care to active consumers, in greater electronic contact with their doctor through email or telemedicine.[14] Optimists believe that increasing consumer and provider involvement will drive an improvement in the quality of health care.[13] The American Medical Informatics Association has already envisaged the future and established three bold goals for 2008: a virtual health care databank, national health care knowledge bases, and a personal clinical health record.[42] But despite the overwhelming urge to develop something because of the ability to do so, the time honoured principles of evidence based medicine are likely to be needed to ensure that future internet developments have a beneficial impact on health care.[27]

CONCLUSION

The internet has expanded from defence to academic, commercial, and medical institutions, is now global, and is increasingly accessed at home. The greatest threats to our use of the internet will be expensive telecommunications, intellectual property rights, and data protection regulation.[16] Most of all, the expansion of web sites, mailing lists, and discussion forums will make an up to date knowledge of the best resources mandatory, for which this and subsequent review articles serve as a baseline, with updates in the *JNNP*'s monthly Neuronline section.

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