資料３

Internet Society Perspectives on Internet Content Blocking: An Overview とその背景に関して

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Internet Society(以下 ISOC)は、健全なインターネットの普及と高度化を事業内容とする非営利団体であり、インターネットの技術標準を策定する Internet Engineering Task Force(IETF)のリーガルアンブレラの機能を果たすとともに、インターネットの運用に関係するすべてのステークホルダ(企業・組織)によるインターネットに関係する政策の調査と提言を行っている、いわば、技術・運用・政策に関するグローバルインターネットの運営に関する責任を持つエキスパートから構成される団体である。

Internet Society Perspectives on Internet Content Blocking: An Overview[1](以下 本文書)は、ISP・キャリアで実施するコンテンツ遮断方法（IP アドレス、DPI(Deep Packet Inspection)、URL ベース、プラットフォーム(検索エンジン)ベース、DNS ベースの 5 つ）を列挙して、それぞれの技術的解説と得失を明らかにしたアセスメント文書であり、2017 年 3 月に公開された。要約としては、21 ページに各遮断方法と評価結果の一覧、22 ページの結論、そして 6 ページのコンテンツ遮断による不利益の一覧が有用である。これらに関しては、JPNIC が私訳を提供したので、次ページ以降に付した。

本文書は、各国で（法制化を含め）実施されていく状況の中で、ISP・キャリアによるコンテンツ遮断が、技術的な有効性が乏しいにもかかわらず、グローバルインターネットに対する影響が顕著であることを憂慮してまとめられた。グローバルインターネット運営の観点から、ISP・キャリアにおけるコンテンツ遮断を法制化することに関する問題点を、以下に挙げる。

1. ISP・キャリアにおけるコンテンツ遮断には幾重にも回避策があって効果が薄い[2]上に、すべての ISP・キャリアが対応する必要がある、非常に大きなコストがかかる対処方法である。（権利者、侵害者以外の第三者において費用がかかり、かつ費用対効果が著しく悪い）
2. 利用者にとって回避策の検索と実装は、悪性コンテンツサイトの検索と発見と同程度に容易である。
3. インターネットはグローバルに運営されており、その一部だけに適用されるローカルルールはグローバルに効果がない。仮にローカルな遮断が一時的に効を奏したとしても、単純に犯罪行為を国内法制では対応できない形(地下化、巧妙化)追い込むのみであり、今後の本質的な対応がより取りづらくなる。結果、経済的損失も減らないことが想定される。（本文書 p.6 表・第 6 項）
4. アクセス遮断などの措置はあくまで一時的なものであるべき（本文書 p.23 g）だが、法制化された場合、手段の硬直化を招くだけでなく、法の網の目をくぐる回避策の連鎖を呼ぶ結果となりかねない。
5. 有効な対策は、コンテンツのテイクダウン（本文書 p.23 a）、Web ブラウザなど利用者内システムにおけるアクセス遮断（本文書 p.23 e）など、インターネットの末端における措置や、Web サイト運用の資金源の根絶など技術以外の方策である。

[1] https://www.internetsociety.org/wp-content/uploads/2017/03/ContentBlockingOverview.pdf

[2] 回避策の典型例として、代表的な Web ブラウザのひとつ Firefox では、システム指定の DNS に従わず、DNS over HTTPS(DoH)によって Firefox が指定する DNS を参照する方向にある。これはローカルの DNS を信用しない動きの一例ともいえる。 https://blog.ungleich.ch/en-us/cms/blog/2018/08/04/mozillas-new-dns-resolution-is-dangerous/

公共政策の観点から見たインターネットコンテンツ遮断に関する主な問題点を下表にまとめる。

問題点	詳細
回避が容易	十分な動機を持つ者にとっては、本文書で述べられているすべての技術は回避可能。遮断を回避する種々の方策を発見するため、その有効性は低減する。
問題の根源的な解決策とならない	遮断は違法コンテンツを削除するものではない。特定の国家による禁制が国際的な規範に合致しない場合もあるが、違法コンテンツに関する広範な合意がある場合においては、最善の策は当該コンテンツを源から絶つことである。
副次的な被害を及ぼす危険性	合法コンテンツと違法コンテンツが IP アドレス、ドメイン名等のリソースを共有している場合には、コンテンツ遮断策は、違法に関わらずすべてのコンテンツに対するアクセスを遮断する。例えば、Wikipedia 内の一つの記事に対する DNS フィルタリングが、それ以外の何百万もの記事へのアクセスを遮断することとなる。
利用者に及ぼす危険性	自らのインターネットサービスが信頼性やオープン性に欠けると感じた利用者は、フィルターを回避するソフトウェアをダウンロードするなど、他の非標準的な方法を利用する可能性がある。安易な解決策は利用者をさらなるセキュリティリスクに曝すこととなる。
透明性の欠如が進行	透明性と信頼性の高い環境がインターネットの運用には重要である。コンテンツ遮断は透明性を低下させ、ネットワークのオープン性を毀損し、パブリックな情報源としての不信感をもたらす。
サービスの地下化の助長	コンテンツ遮断が一般化すると、地下(underground)サービスや他のネットワーク(alternative network)が構築され、法執行機関が容易に発見できなくなる。例えば、コンテンツをダークウェブに移転することや、トラフィックを VPN 経由にすることなどの行為が行われることとなる。
プライバシーの侵害	ある種のコンテンツ遮断は、利用者の通信内容（暗号化された通信内容も含む）を調査することを要する。第三者が利用者の行為を監視、記録し、暗号化された通信を解読することは、利用者のプライバシーの侵害となる。
人権と適正手続きへの懸念	必要性やバランスについて十分に考量がされないままコンテンツ遮断が導入されると、表現の自由や基本的人権の制限など、重大な副次的損害を及ぼす可能性がある。

Internet Society Perspectives on Internet Content Blocking: An Overview

p.21 “Content Blocking Summarized” 和訳（JPNIC による私訳）

インターネットコンテンツ遮断技術					
	IP アドレスベース	**DPI ベース**	**URL ベース**	**プラットフォーム（検索エンジン）**	**DNS ベース**
概要	IP アドレスやアプリケーション(VPN など)を基に遮断する装置をネットワークに挿入	キーワードや他の内容（ファイル名など）を基に遮断する装置をネットワークに挿入	Web へのリクエストを傍受して URL をブロックリストに照合する装置をネットワークに挿入	アプリケーション事業者（検索エンジンなど）と協同し、要請に応じて表示内容を改変	一定のキャリアレベルもしくは ISP レベルで特定のドメイン名の検索をブロックする改変を加えた DNS サーバを設置
効果	IP アドレスは容易に変更でき、コンテンツも容易に移設できるため、**この技術の効果は貧弱**。遮断回避に積極的でない相手にのみ作用	遮断対象の情報の特徴抽出が容易であれば非常に効果的。概括的遮断(例:アダルトコンテンツ)の場合、コンテンツが暗号化されている場合には**この技術は極めて非効果的**	**全種類の情報に対するアクセス遮断に作用する一般的な技術**ながら、新たなページや小サイト、また暗号化された Web サーバは遮断から簡単に漏れる	(例えば)検索エンジンには独占状態はあり得ず、顧客嗜好は常に変化する。**この種類の遮断の効果はは表面的で、貧弱である**	DNS 遮断はコンテンツ公開者、エンドユーザー双方から容易に回避可能。遮断対象のドメイン名に非常に少量のコンテンツしかなく、その全てを遮断してもいい場合にのみ効果的。**技術的に課題が多く、オーバーブロッキングであり、回避も容易なことからこの技術は非効果的**
影響範囲	挿入した装置の「背後」全て	挿入した装置の「背後」全て	挿入した装置の「背後」の利用者で、装置が傍受・評価できるトラヒックに対して	遮断を実施した検索エンジンの利用者	改変された DNS サーバの利用者。ISP・キャリアレベルで実施可能
作用のきめ細かさ	**合法非合法問わず、IP アドレスが示すサーバ上の全コンテンツに作用**。データが暗号化されていても作用する。	**遮断ルールに適合するコンテンツのみに作用**。暗号化された Web ページへの適用にはプロキシサーバが必要	**個別の Web ページやパーツに作用**。暗号化された Web ページへの適用にはプロキシサーバが必要	**個別の Web ページやパーツに作用**。通常個別 URL レベル。	**合法非合法問わず、当該ドメイン名で供される全てのコンテンツに作用**。コンテンツ配信への利用は効果的でない
種別	コンテンツ遮断	コンテンツ遮断	コンテンツ遮断	アクセス困難化	アクセス困難化

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	IP アドレスベース	DPI ベース	URL ベース	プラットフォーム（検索エンジン）	DNS ベース
副次的損害の大きさ	大きなサーバへの適用は合法コンテンツをも遮断するため誤検知率の過大を招く	遮断ルールの品質に依って誤検知率は極小から極大までふれる。高品質ルールの設定は困難	多くの URL フィルターはトラフィックを種別分けする商用サービスの転用によるもの。メインストリームの遮断には具体的な適用が可能ながら、少量の特殊用途の場合誤作動率が極めて高い	各ページの遮断は個別に要請されるため誤検知率は低いと考えられる。正当でない要請が不適切な情報遮断を招き得る問題がある	大きなサーバ群に使われるドメイン名への適用は合法コンテンツをも遮断するため誤検知率の過大を招く。CDN が利用される場合、非効果的（あるいはきわめて高いレベルの誤検知を引き起こす）
一般的な回避策	コンテンツ公開者は、IP アドレスの変更、コンテンツの移転、CDN の利用などで回避しうる。VPN 利用者は IP アドレスを隠匿することで回避。	この種類の遮断は複数レイヤーの暗号化で効果的に回避可能。ルールのつくりが悪い場合、テキストの小変更だけで容易に遮断をバイパス可能	この種類の遮断は複数レイヤーの暗号化で効果的に回避可能。また非標準のアプリケーション層を使うとしばしば効果的に回避可能。	利用者は容易に、別のプラットフォーム、例えば別の検索エンジンを選択可能	利用者は、自分の DNS を使う、あるいは改変されていないパブリックな DNS サーバを（典型的には VPN 経由で）参照することで回避可能。
副作用または技術的な問題	IP アドレスリストが長くなると保守困難で障害を引き起こしがちであり、かつメモリ資源を浪費する。この種類の遮断を行う専用機は高速処理を行うため、性能問題は一般的ではない	コンテンツに応じたフィルタリングは性能コストが顕著であり、（潤沢なメモリ資源を準備しない限り）多くの環境で実際的ではない。プロキシサーバが利用された場合は、セキュリティに重大な逸失が起こる	URL フィルタリングは性能、全体的な速度、信頼性などの問題を引き起こし得る。プロキシサーバが利用された場合はセキュリティの大きな低下となる	検索エンジンにおける情報の「抑制」はそれ自体が表示結果への論争を呼ぶ	改変サーバが配備された場合、DNS セキュリティは逸失される

結論

さまざまなコンテンツ遮断技術、その効果および副作用を理解することは、政策立案者がこれらの対策の利用を検討するため、およびインターネットの擁護者およびその他の人がコンテンツ遮断の実施に影響を及ぼしたい場合の両方にとって重要である。

すべてのコンテンツ遮断技術は 2 つの主要な欠点を持つ傾向にある:

1. 問題を解決しない
コンテンツ遮断技術はインターネットからコンテンツを取り除かず、違法な活動や犯罪の遂行を止めず、単にコンテンツの前に幕を張るだけである。裏に潜んだコンテンツは同じ場所に残る。

2. 副次的被害を引き起こす
すべてのコンテンツ遮断技術は過剰な遮断（オーバーブロッキング、意図したよりも広範囲を遮断してしまうこと）および不十分な遮断（意図したよりも狭い範囲を遮断してしまうこと）に苦しむことになる。また、利用者を（遮断の回避を試みることで）リスクにさらすこと、インターネットの透明性と信頼の減少、サービスが地下化すること、利用者のプライバシー侵害といった他の被害をインターネットに対して引き起こす。これらはコンテンツ遮断の議論と同時に検討されなければならない代価である。

勧告

Internet Society はインターネット上での違法コンテンツおよび違法な活動に対抗するための最も適切な方法は、その源において対処することであると信じる。オンラインコンテンツへのアクセスを遮断するためにフィルターを使うのは非効率であり、非効果的となり得る。そして無実のインターネット利用者に影響する、副次的被害を引き起こしがちである。

我々はインターネット上の違法なコンテンツに関して懸念する政策立案者向けに、次の 2 つの主要な戦略をお勧めする:

1. **問題の源で対処**:インターネットへの最も損害を少なくする取り組み方は、違法コンテンツおよび違法行為にその源で「攻撃」することである。その源から違法コンテンツを取り除き、加害者への執行に着手することは、コンテンツ遮断の負の作用を回避するとともに、違法コンテンツの除去に際してより効果的である[3]。オンライン違法コンテンツは国境および一国の法を超えて拡張するため、複数の法域およびステークホルダー間の協力は成功に際して必須条件である。

2. **優先順位付けおよび代替手段の利用**:状況次第で、異なる手段がかなり効果的なことがある。例と

[3] 各国当局がコンテンツの消費者と同じ法域にいる際には、違法コンテンツを源で除去するのは、国境を超える対処における複雑さとオーバーヘッドを回避できるので容易である。国境を超えるインターネットの文脈においては、提供者と消費者が異なった法域におり異なった法律の適用対象になるかもしれず、源でコンテンツを除去するのは困難となり得ることは認識している。それでもなお我々は、この困難を、インターネットを害さないより効率的な解決策を見極める努力を断念する理由とすべきではないと考える。

して：

- サービスプロバイダー、法執行機関、各国関係当局間での効果的な協調が違法コンテンツ被害者への支援、および犯罪者に対する執行に対する追加手段を提供する可能性がある[4]。
- 何が適法で何が適法でないかに関する情報を利用者が受け取る信頼の環境を構築することが、利用者による自己管理を改善することができる。
- いくつかの事例（ペアレンタルコントロールなど）では、利用者がフィルターを自分の機器で利用する権限を同意により与えることが、効果的かつインターネットへの損害を最小限にすることができる。
- 自発的な、または法的根拠にて、ギャンブルサイトなどのサイトではサービスが禁じられている国々からのアクセスを防止するために地理的位置情報を使うことが可能。

弊害の最小化

すべてのコンテンツ遮断技術、とりわけ公共政策での検討に基づくものは重大な欠陥がある。すべての技術は不完全にしか機能せず、回避することが可能である。そのため、また前に書いた理由により、コンテンツ遮断には反対することを勧告する。

それでもなお、これらの技術はまだ利用されている。この現実を認識して、我々は弊害を軽減するため、次の詳細ガイドラインを提供する：

a. コンテンツ遮断以外の選択肢をやりつくす：まず真っ先に、コンテンツをその源で対処するすべての実際的な選択肢や、その他コンテンツ遮断以外の手段を検討しつくすこと。コンテンツ遮断は単純により簡単だからといって続行しようとすべきでない。

b. 透明性：コンテンツ遮断について、根本的な目的および方針と同様、透明性を保つべきである。各国当局は対象となる利用者が自身の権利に対する弊害に関する懸念を表明する機会を与えるようにすべきである。

c. インターネットに対するあなたの責任を熟考：コンテンツ遮断の関係者は全体としてインターネットの安定性、セキュリティおよび復元性を保つという、システムに関する責任を共有していることを自覚するべきである。コンテンツ遮断技術は、インターネットが共同で管理され機能してきたやり方に悪影響を与える。被害は時には直接的であり、時には間接的である。例えば、アクセス遮断を回避しようとする利用者は問題を引き起こしたり、個人のセキュリティを脅かす可能性がある。

e. グローバルに考え、ローカルに行動する：ローカルなコンテンツ遮断やフィルタリングは、グローバルに影響する可能性があるものの、一般的に、コンテンツ遮断を極力局所的にすることは、グローバルへの影響を最小化する。理想的には、利用者の末端でブロッキングするのが最も効果的で、

[4] 例えば、違法な取引を特定し制限するのに、金融業界とのパートナーシップを使うことができる。

副次的被害を最小化する。

f. **ステークホルダーの関与**：ポリシー策定および実装は、弊害を最小化するために適切な段階が踏まれたことを保証するために、技術、経済、消費者権利その他の専門家を含む、幅広いステークホルダーが関与すべきである。

g. **一時的なものに留める**：いかなるコンテンツ遮断手段も一時的なものとすべきである。ブロッキングする理由が存在しなくなればできるだけ早く遮断は除去されるべきである。コンテンツ遮断策を回避するために違法コンテンツが移動することはよくあることで、その場合にコンテンツ移動後も長期間ブロッキング手段が残るのもよくあることである。

h. **正当な法的プロセスに従うこと**：違法コンテンツへのいかなる遮断命令も法によって担保され、独立して再検討され、正当な目的を達成するために、極力対象を狭く設定されなければならない。違法活動に対処する上で最も制限の少ない手段を講じることが最優先とされるべきである。インターネットサービスプロバイダーまたは他のインターネット仲介者は事実上の法執行機関になるべきではない。つまり、行為もしくはコンテンツが違法であるとする判定が要求されるべきでないということである。

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March 2017

Internet Society

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Foreword

The use of Internet blocking by governments to prevent access to illegal content is a worldwide and growing trend. There are many reasons why policy makers choose to block access to some content, such as online gambling, intellectual property, child protection, and national security. However, apart from issues relating to child pornography, there is little international consensus on what constitutes appropriate content from a public policy perspective.

The goal of this paper is to provide a technical assessment of different methods of blocking Internet content, including how well each method works and what are the pitfalls and problems associated with each. We make no attempt to assess the legality or policy motivations of blocking Internet content[1].

Our conclusion, based on technical analyses, is that using Internet blocking to address illegal content or activities is generally inefficient, often ineffective and generally causes unintended damages to Internet users.

From a technical point of view, we recommend that policy makers think twice when considering the use of Internet blocking tools to solve public policy issues. If they do and choose to pursue alternative approaches, this will be an important win for a global, open, interoperable and trusted Internet.

[1] Readers interested in legal assessments of content blocking could visit the following resources:
- Article 19: https://www.article19.org/data/files/medialibrary/38657/Expression-and-Privacy-Principles-1.pdf
- Council of Europe: http://www.coe.int/en/web/freedom-expression/study-filtering-blocking-and-take-down-of-illegal-content-on-the-internet

Introduction

The Internet's evolution into a worldwide societal phenomenon has much to credit to the content and services that have taken advantage of the network's unique architecture. Entire economies depend on cross-border content flows. Daily innovations have the potential to disrupt entire industries. The Internet is now a critical part of democratic processes and policy discussions. Personal relationships are created and broken online.

The trend is not slowing down. According to estimates[2], Global Internet traffic in 2020 will be equivalent to 95 times the volume of the entire global Internet in 2005. The number of devices connected to IP networks will be three times as high as the global population in 2020.

Yet, the Internet also contains content that policy makers, legislators, and regulators around the world want to block. From blocking foreign gambling websites in Europe and North America to blocking political speech in China, the use of Internet content blocking techniques to prevent access to content considered illegal under certain national laws is a worldwide phenomenon. Public policy motivations to block Internet content are diverse, ranging from combating intellectual property infringement, child abuse material and illegal online activities, to protecting national security.

The objective of this paper is neither to assess such motivations nor to qualify whether a certain type of blocking is good or bad from an ethical, legal, economic, political or social perspective. Instead, we will provide a technical assessment of the benefits and drawbacks of the most common blocking techniques used to prevent access to content deemed illegal. The aim is to help readers understand what each technique can, and cannot, block, along with the side effects, pitfalls, trade-offs, and associated costs.

Our conclusion is that the use of Internet blocking to address illegal content is generally inefficient, often ineffective, and prone to cause unintended collateral damages to Internet users, summarized further in the table on page 6.

From a technical point of view, **we call on policy makers to think twice** about the use of such measures and invite them to prioritize their responses focusing primarily on alternative measures that focus on addressing the issue at the source (see more detailed recommendations at the end of this paper, including guidance on how to minimize the negative effects of such measures.).

It should further be noted that this paper is not focusing on blocking measures when implemented for regular network management or security reasons (e.g. addressing spam, malware). In such cases, some of the same tools we describe in this paper can often be effective to achieve the intended aims.

Sidebar:
Filtering, Blocking, or Censorship?

When describing Internet filtering, terms such as "filtering," "blocking," "shut down," and "censorship" all come up (along with several others). From the point of view of the user, the term chosen is less important than the effect: some part of the Internet is inaccessible. For policy makers and digital activists, choosing a particular term is usually more driven by semantic overtones than technical correctness. The word "censorship" carries a strong negative connotation, while "filtering" seems a more gentle and harmless operation, like removing unwanted seeds from a glass of orange juice. We have chosen to use "blocking" as a simple and straightforward term throughout this paper.

[2] Cisco® Visual Networking Index: http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.html

The table below summarizes the major drawbacks associated with Internet content blocking based on public policy considerations:

Issue	Details
Easily circumvented	All of the techniques described in this paper can be evaded by sufficiently motivated users. As users discover the many ways to work around content blocking, the effectiveness of the blocking will be reduced.
Doesn't solve the problem	Content blocking does not remove the content considered illegal. In some cases, a national ban may be incompatible with international norms, but where there is wide-ranging agreement on illegal content, the best solution to the problem is removal of the content at the source.
Causes collateral damage	When both legal and illegal content share the same IP address, domain name, or other characteristics, content blocking will block access to everything: illegal and legal. For example, blocking access to a single Wikipedia article using DNS filtering would also block millions of other Wikipedia articles.
Puts users at-risk	When local Internet service is not considered reliable and open, Internet users may use alternative and non-standard approaches, such as downloading software that redirects their traffic to avoid filters. These makeshift solutions subject users to additional security risks.
Encourages lack of transparency	A transparent and trusted environment is important to the successful operation of the Internet. Content blocking eliminates this transparency, undermining the open nature of the network and causing distrust of public information sources.
Drives service underground	When content blocking becomes widespread, "underground" services and alternative network overlay structures will be established, taking the content out of easy view of law enforcement. For example, content may move to the Dark Web or users may tunnel traffic through VPNs.
Intrudes on privacy	Several types of content blocking require the examination of the user's traffic, including encrypted traffic. When third parties monitor what Internet users do, record transactions, or break the basic encryption security of the Internet, users' privacy is violated.
Raises human rights and due process concerns	Implemented without due regards to notions such as necessity and proportionality, content blocking has the potential to cause significant collateral damage, restriction of free and open communications, and put limits on the rights of individuals.

Motivations for Blocking Content

In this paper, we focus on **blocking based on public policy considerations** and its effects on the Internet and Internet users (see side-bar for other motivations for content blocking)

Blocking based on public policy considerations is used by national authorities to restrict access to information (or related services) that is either illegal in a particular jurisdiction, is considered a threat to public order, or is objectionable for a particular audience.

For example, there’s a common desire in most countries to block access by children to obscene material, or access by anyone to child abuse material. Depending on the local legal environment, content may also be blocked if it violates intellectual property laws, is considered a threat to national security, or is prohibited for cultural or political reasons.

One of the challenges leading national authorities to use Internet content blocking measures is that different actors delivering the source’s content to consumers may be in different countries, with different laws covering what is and is not “illegal content”. Moreover, the global environment of the Internet makes stopping the source of illegal content more complicated than simply shutting down a local server. For example, the person providing the content, the servers hosting the content, and finally the domain name pointing to the content may in three different countries, all beyond the jurisdiction of an individual national authority. This highlights the importance of cooperation across jurisdictions and the need for close coordination with non-governmental stakeholders.

Other Types of Motivations for Blocking Content

In this paper, we focus on blocking based on public policy considerations, but there are two other common reasons that network blocking is put into place. The first is **preventing or responding to network security threats.** This type of blocking is very common. For example, most enterprises attempt to block malware from entering their networks. Many Internet Service Providers (ISPs) are putting in blocks for malicious traffic exiting their networks, such as from hijacked IoT devices (e.g. web cams). Email filtering is extremely common, and includes blocking unwanted bulk email as well as malicious email such as phishing messages. These types of blocking are not discussed in this paper.

A second reason for blocking is **managing network usage.** A growing area of Internet content blocking is based on network, bandwidth, or time management requirements, rather than particular types of content. For example, employers may wish to restrict access to social networking sites for their employees while still offering Internet access at the desktop. ISPs may block or permit, throttle or accelerate certain content based on contracted services. Network usage management is rarely a public policy issue, except when it steps into the area of anti-competitive behavior. Readers interested in Network Neutrality will find references in For Further Reading, page 26.

Overview of Content Blocking Techniques

Each technique has both technical and policy limitations and consequences that need to be considered when any type of content blocking is being proposed. The goal of this paper is to provide a common way to evaluate their efficacy and side effects. Readers interested in a more technical discussion of content blocking will find references to IETF technical documents in For Further Reading, page 26.

This paper will assess the following types of content blocking:

- IP and Protocol-based blocking
- Deep Packet Inspection-based blocking
- URL-based blocking
- Platform-based blocking (especially search engines)
- DNS-based blocking

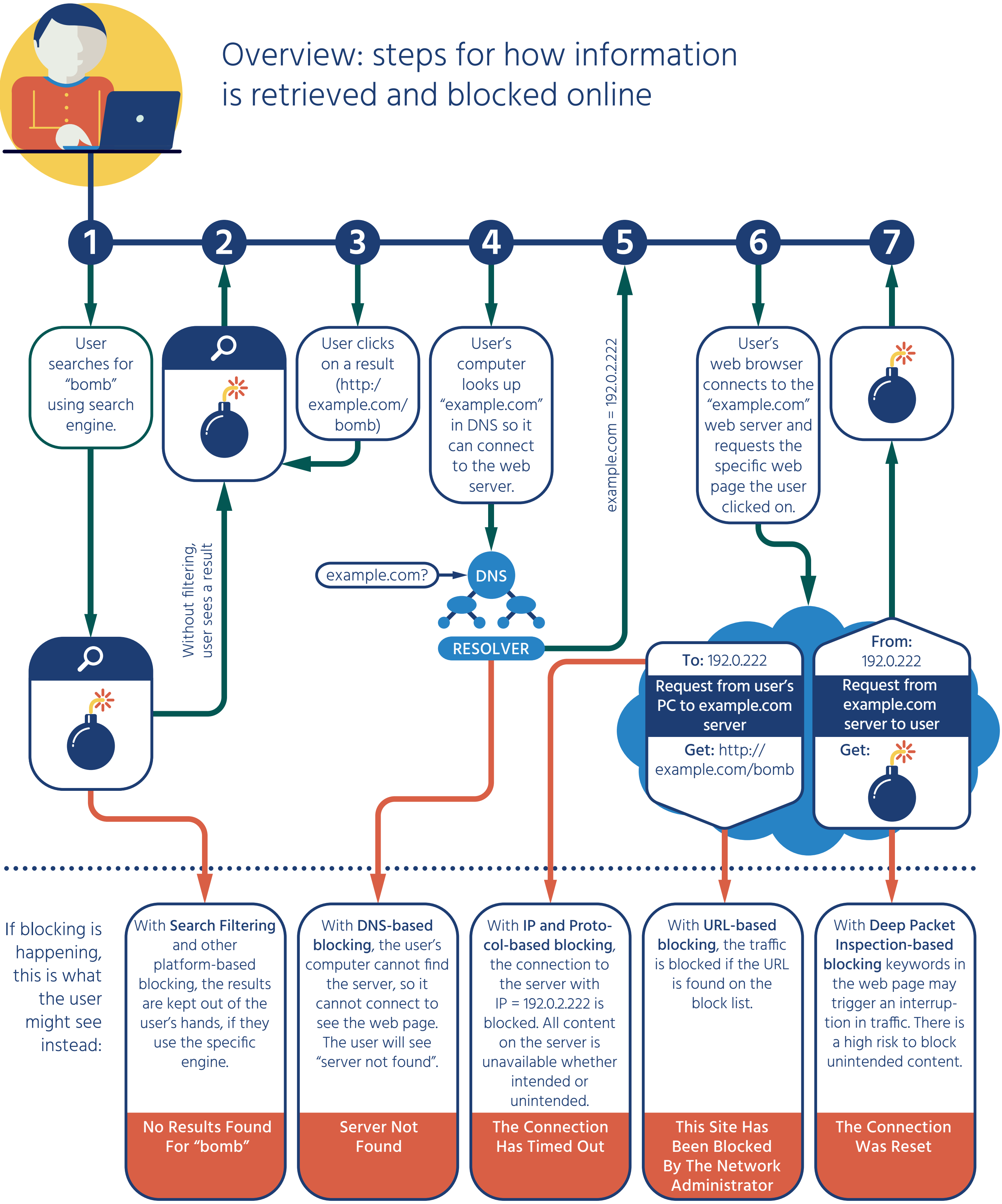
We chose these five types of blocking because they target the elements of a typical end-user cycle of finding and retrieving information, including the use of a search engine and viewing information with a web browser or similar tool. This cycle is very familiar to policy makers, themselves Internet users, and these are the operations that most blocking based on public policy considerations tries to disrupt.

In the diagram to the right, we show the steps that a typical Internet user might take to find information, as well as the kinds of blocks that have been used to disrupt this cycle when blocking based on public policy considerations is implemented. In our diagram, an Internet user searches for some type of content using a search engine (step 1), a common starting point. The search engine returns a set of results (step 2), and the user selects one and clicks on the result (step 3). One type of blocking, Platform-based Blocking, is used to disrupt this part of the cycle by blocking some results coming back from the search engine.

The user's computer tries to find the server hosting the data in the Internet's DNS (steps 4 and 5). A second type of blocking, DNS-based Blocking, is used to disrupt this part of the cycle.

Then, the user's web browser tries to connect to the server (step 6). This part of the cycle can be blocked using three other types of blocking: IP and Protocol-based Blocking, URL-based blocking, and Deep Packet Inspection-based blocking.

Overview: steps for how information is retrieved and blocked online



1 User searches for "bomb" using search engine.

2 Without filtering, user sees a result

3 User clicks on a result (http:/ example.com/ bomb)

4 User's computer looks up "example.com" in DNS so it can connect to the web server.

example.com? DNS RESOLVER

5 example.com = 192.0.2.222

6 User's web browser connects to the "example.com" web server and requests the specific web page the user clicked on.

To: 192.0.2.222

Request from user's PC to example.com server

Get: http:// example.com/bomb

7

From: 192.0.2.222

Request from example.com server to user

Get:

If blocking is happening, this is what the user might see instead:

With **Search Filtering** and other platform-based blocking, the results are kept out of the user's hands, if they use the specific engine.

No Results Found For "bomb"

With **DNS-based blocking**, the user's computer cannot find the server, so it cannot connect to see the web page. The user will see "server not found".

Server Not Found

With **IP and Protocol-based blocking**, the connection to the server with IP = 192.0.2.222 is blocked. All content on the server is unavailable whether intended or unintended.

The Connection Has Timed Out

With **URL-based blocking**, the traffic is blocked if the URL is found on the block list.

This Site Has Been Blocked By The Network Administrator

With **Deep Packet Inspection-based blocking** keywords in the web page may trigger an interruption in traffic. There is a high risk to block unintended content.

The Connection Was Reset

Of course, the Internet is much more than search and web browsers, and many of the techniques discussed below are effective at blocking more than web pages. For example, use of VPN services to encrypt and hide traffic can often be blocked using a combination of Deep Packet Inspection-based blocking and IP/Protocol-based blocking.

These types of blocks may be applied very specifically (such as a particular document on a particular web site) or very generically (such as "material on an issue" or "Voice over IP services").

Where Does Content Blocking Occur?

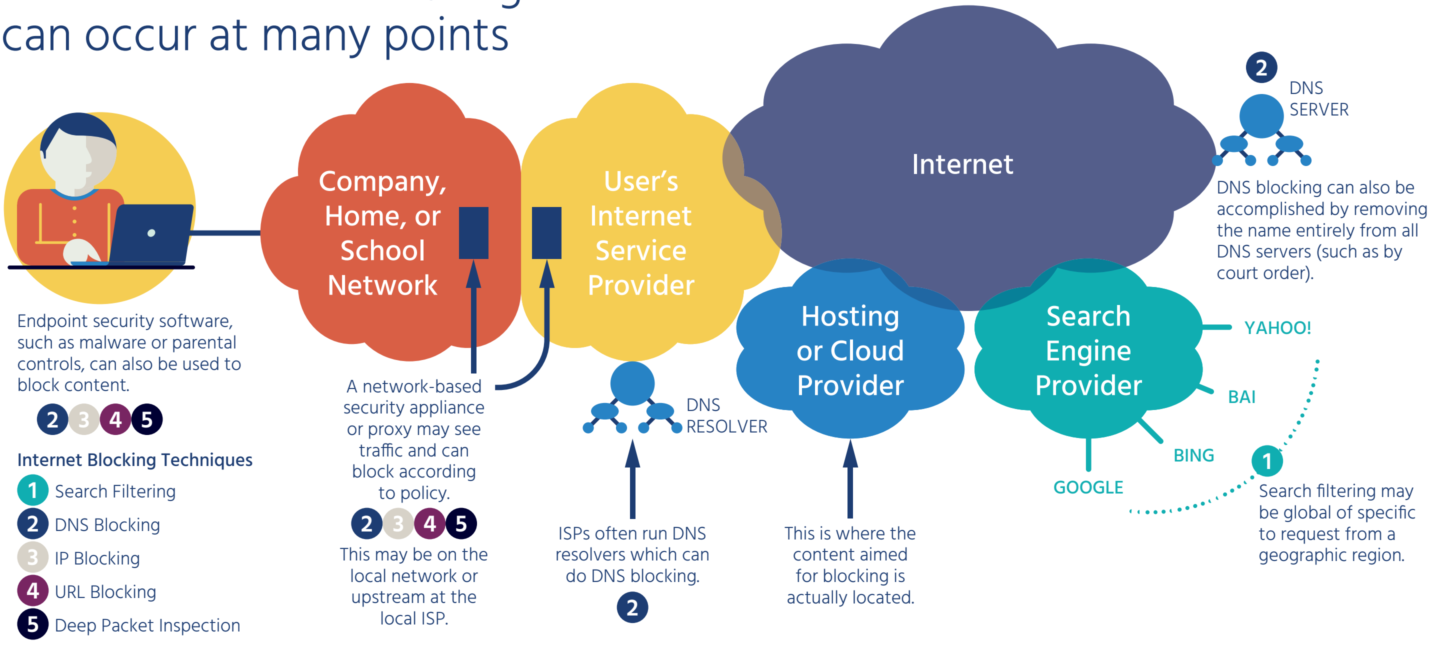
Many of the content blocking techniques discussed here can be used at different points, as shown in the table below.

National level	When mandated by government policy, all traffic entering or leaving a country may be subject to content blocking. This requires tight control of all cross-border connections by means of a national gateway or national firewall, or could be imposed on all carriers and ISPs in a country in parallel.
Carrier and ISP level	Individual telecommunications carriers, including mobile carriers and traditional ISPs, may install blocking tools.
Local network level	End-user laptop and desktop devices are typically connected to home, corporate, or school networks rather than directly to a carrier. These local networks may have blocking installed, usually based on network management or security policy rather than governmental policy.
Endpoint level	Software may be installed directly on end-user computers that enforces the blocking policy. This is very commonly used in both home and corporate networks, usually for security reasons but also for network management or parental control reasons.

Note that in the case of blocking based on public policy considerations, the majority of measures are being applied at the first two levels (national, carrier, and ISP levels).

The diagram below summarizes some of the main locations where blocking can occur, and which types of blocking can occur at each point.

Internet Content blocking can occur at many points



Company, Home, or School Network
User's Internet Service Provider
Internet
Hosting or Cloud Provider
Search Engine Provider
DNS SERVER
DNS RESOLVER
YAHOO!
BAI
BING
GOOGLE
2
1
2

Endpoint security software, such as malware or parental controls, can also be used to block content.

2 3 4 5

A network-based security appliance or proxy may see traffic and can block according to policy.

2 3 4 5

This may be on the local network or upstream at the local ISP.

ISPs often run DNS resolvers which can do DNS blocking.

This is where the content aimed for blocking is actually located.

DNS blocking can also be accomplished by removing the name entirely from all DNS servers (such as by court order).

Search filtering may be global of specific to request from a geographic region.

Internet Blocking Techniques

1 Search Filtering
2 DNS Blocking
3 IP Blocking
4 URL Blocking
5 Deep Packet Inspection

Sidebar:
Endpoint Content Blocking

This paper focuses on Internet content blocking based on public policy considerations.

Yet, it is important to note that one of the most effective ways to block undesired content is through the use of software installed on the user's device, commonly called the "endpoint" because it is the last point of the connection between the user and the Internet. Most computer users make use of endpoint software to block malware (viruses, Trojan horses, and phishing), whether installed personally or by an organizational IT group.

Endpoint content blocking software is also used by organizations to block content for other reasons. For example, libraries often install this type of software on public computers to block the viewing of pornography by patrons, and parents may use it to block unwanted content from their children.

Endpoint content blocking may use many of the techniques described in this paper, including content scanning, URL categorization, IP address blocking, and DNS interception. Generally, the blocking and analysis occurs on the actual endpoint. However, vendors of this software are increasing also using cloud-based tools including content scanning and DNS-based blocking, in cooperation with a small amount of endpoint software. In these newer solutions, some or all of the Internet content may pass through a cloud-based service. The advantage of moving the decision-making to the cloud is that endpoints do not have to be constantly updated, and the performance impact of evaluating content is moved from the user's computer or smart phone to an easily scaled cloud of computers. When traffic is routed through a third party, though, this also creates privacy issues by making the content available to the third party and, if poorly implemented, security issues arise well.

Content Blocking Types Evaluated

The five common content blocking types are distinct in what they block and how they operate.

Below, the content blocking techniques are discussed in greater detail and are evaluated against four specific criteria[3]:

1. **Which sets of users and Internet services are affected** by this technique? What sets are unaffected?

2. **How specific** is the technique in preventing access to particular content? How much collateral damage (unintended blockage) is created by this blocking technique?

3. **How effective** is this technique in blocking content? What types of users and content providers are able to circumvent this technique?

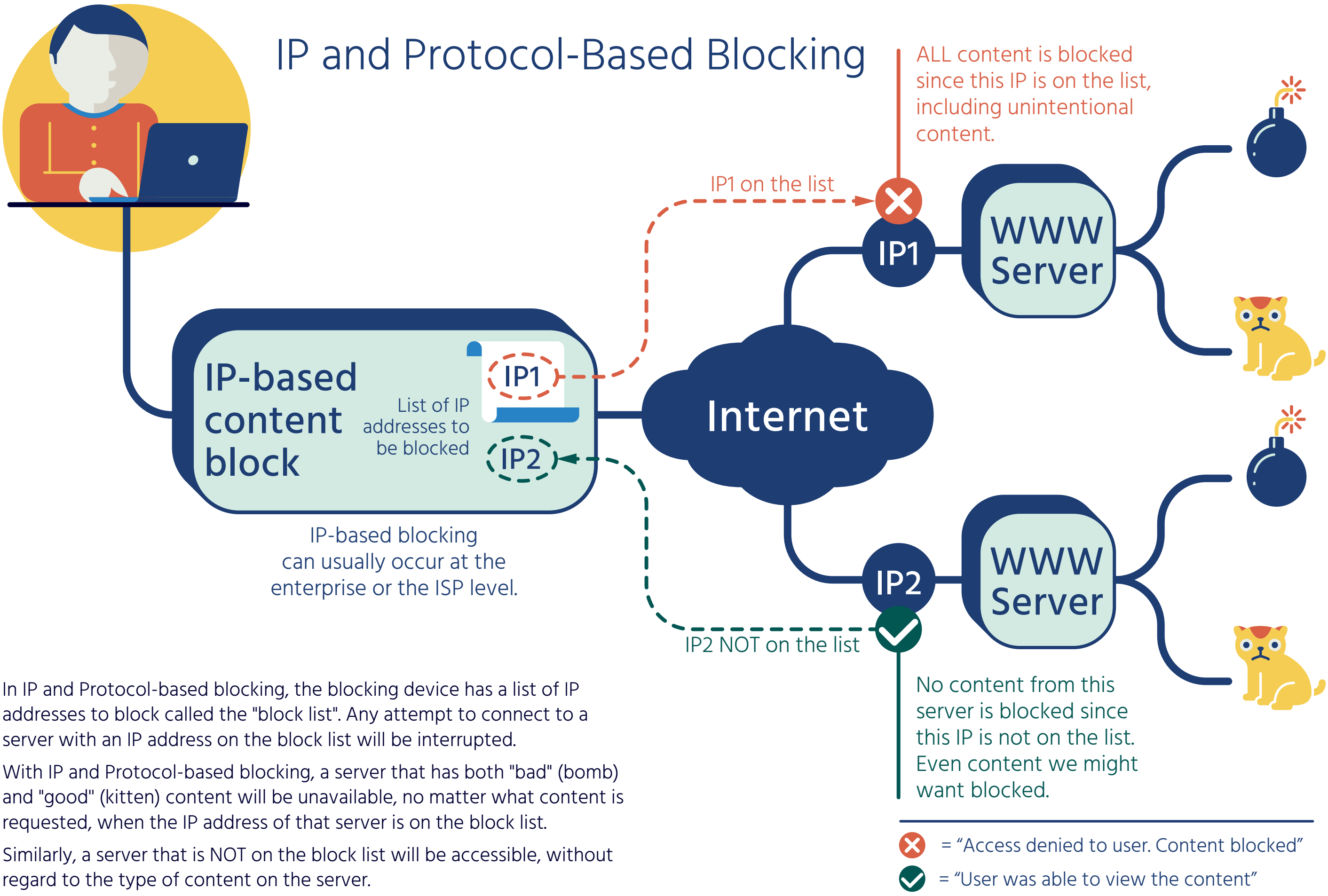
4. **What are common side-effects** of this technique? What technical issues are caused by this technique? What non-technical issues, such as impact on trust and fundamental rights, are raised in using this technique?

[3] These criteria are taken from Internet RFC 7754, "Technical Considerations for Internet Service Blocking and Filtering."

IP and Protocol-Based Blocking

IP-based blocking places barriers in the network, such as firewalls, that block all traffic to a set of IP addresses. Protocol-based blocking uses other low-level network identifiers, such as a TCP/IP port number that can identify a particular application on a server or a type of application protocol. These simplest approaches to blocking content don’t actually directly block content-they block traffic to known IP addresses or TCP/IP ports or protocols associated with some content or an application. IP and protocol-based blocking may also be done by software on user’s computers, typically for network security purposes.

For example, if the goal was to block all content hosted in the mythical country of Elbonia, IP blocking could be used if the set of all IP addresses hosting content in Elbonia were known. Similarly, if the goal was to block all VPN services (which are used to encrypt traffic and hide both the destination and the content), protocol-based blocking could be used to stop VPN services using well-known protocols or TCP/IP port numbers.


IP and Protocol-Based Blocking
IP-based content block
List of IP addresses to be blocked
IP1
IP2
IP1 on the list
IP2 NOT on the list
Internet
IP1
IP2
WWW Server
WWW Server
☒ = “Access denied to user. Content blocked”
✓ = “User was able to view the content”

ALL content is blocked since this IP is on the list, including unintentional content.

No content from this server is blocked since this IP is not on the list. Even content we might want blocked.

IP-based blocking can usually occur at the enterprise or the ISP level.

In IP and Protocol-based blocking, the blocking device has a list of IP addresses to block called the "block list". Any attempt to connect to a server with an IP address on the block list will be interrupted.

With IP and Protocol-based blocking, a server that has both "bad" (bomb) and "good" (kitten) content will be unavailable, no matter what content is requested, when the IP address of that server is on the block list.

Similarly, a server that is NOT on the block list will be accessible, without regard to the type of content on the server.

A variation on IP blocking is throttling of traffic. In this scenario, not all traffic is blocked, only a certain percentage. Users may perceive the service as very slow, or as simply going "up and down." This can be used to discourage users from using a service by making it seem unreliable, or encourage the use of alternative services, without revealing that blocking is occurring. (This can also be done for network and bandwidth management reasons at both the ISP or enterprise level.)

Both IP and Protocol-based blocking use devices that sit between the end-user and the content, and thus requires the blocking party (such as the user's ISP) to have complete control over the connection between the end-user and the Internet. A user who is not "behind" the blocking device, or who uses technology such as a VPN that conceals the true destination of their traffic, will not be affected by this type of blocking.

Generally, IP blocking is a poor filtering technique that is not very effective, is difficult to maintain effectively, has a high level of unintended additional blockage, and is easily evaded by publishers who move content to new servers (with new IP addresses).

IP blocking also does not work when information providers use content delivery networks (CDNs), since the IP addresses of the information are highly dynamic and constantly changing.[4] CDNs also use the same IP address for many different customers and types of content, causing a high level of unintended service interruption.

IP and protocol blocking work better when used to block specific applications, rather than specific content. For example, VPN traffic may be blocked by TCP/IP port and protocol blocks, combined with IP address blocks of known public VPN services. This is a common and highly effective technique.

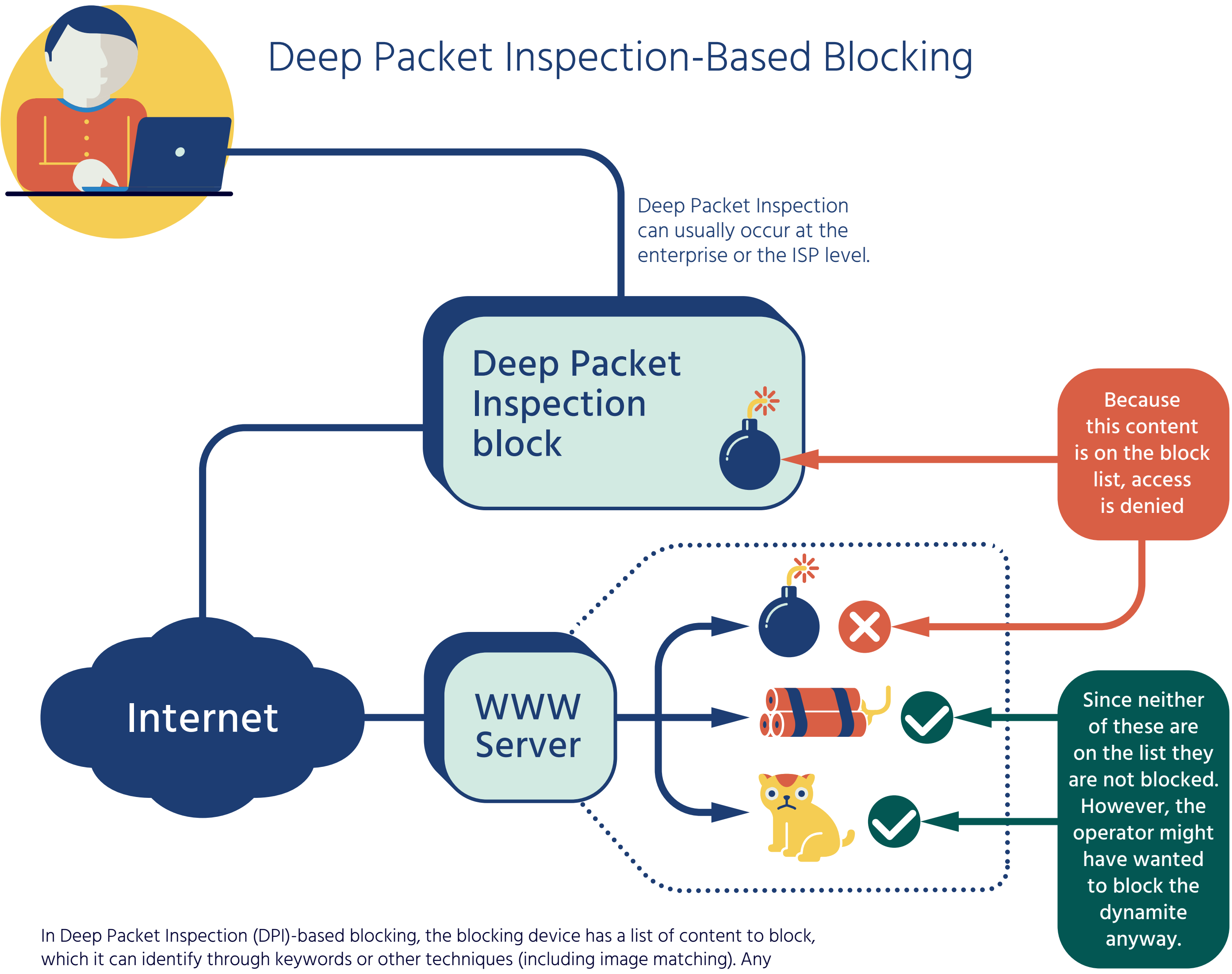
IP blocking is also most effective when the content is hosted in a particular server in a specific data center, or a very specific set of files are of concern. IP-based blocking is **not** very effective for larger hosting services distributed across many data centers or which use content distribution networks (CDNs) to speed access.

[4] A content distribution network is a large, geographically distributed network of servers that speed the delivery of web content to Internet users. Large CDNs have hundreds of thousands of servers in many countries to give faster access to their customers' content. CDNs store copies of their customers' text, image, audio, and video content in their own servers around the "edges" of the Internet, so that user requests can be served by a nearby CDN edge server rather than the customer's centralized servers.

Deep Packet Inspection-Based Blocking

Deep Packet Inspection (DPI)-based blocking uses devices between the end user and the rest of the Internet that filter based on specific content, patterns, or application types. This type of network blocking is computationally very intensive and thus costly, because all content must be evaluated against blocking rules. DPI blocking may also be done by software on user's computers, typically for network security purposes.

DPI blocking requires some type of signature or information about the content to be effective. This may be keywords, traffic characteristics (such as packet sizes or transmission rates), filenames, or other content-specific information. DPI blocking is used very effectively to block or throttle certain applications (such as peer-to-peer file sharing or Voice over IP [VoIP] traffic) and data file types (such as multimedia files).


Deep Packet Inspection-Based Blocking
Deep Packet Inspection can usually occur at the enterprise or the ISP level.
Deep Packet Inspection block
Because this content is on the block list, access is denied
Internet
WWW Server
Since neither of these are on the list they are not blocked. However, the operator might have wanted to block the dynamite anyway.

In Deep Packet Inspection (DPI)-based blocking, the blocking device has a list of content to block, which it can identify through keywords or other techniques (including image matching). Any attempt to download unencrypted content that matches the list will be interrupted.

With DPI, both false positives (blocking content incorrectly) and false negatives (failing to block content as intended) are common. DPI is also difficult to do properly when the traffic is encrypted.

In the diagram here, the bomb has been blocked because it matches the content. However, the dynamite was not blocked, even if the operator of the DPI device wanted to block it, because the dynamite did not match the content block list.

DPI blocking is very commonly used in enterprises for data leakage protection systems, anti-spam and anti-malware (anti-virus) products, and traffic prioritization (such as boosting the priority of enterprise videoconferencing) network management. However, it can also be used for more policy-based blocking purposes. For example, use of VoIP services not provided by the national telecommunications carrier are often regulated or restricted, and DPI blocking is effective at enforcing those restrictions.

DPI blocking uses devices that can see and control all traffic between the end-user and the content, so the blocking party (such as the user's ISP) must have complete control over an end-user's connection to the Internet. When the traffic is encrypted, as it often is, DPI blocking systems may no longer be effective. These are discussed in greater detail in the sidebar "Encryption, Proxies, and Blocking Challenges" to the right.

DPI blocking is generally an effective technique at blocking certain types of content that can be identified using signatures or other rules (such as "block all Voice over IP traffic"). DPI blocking has been much less successful with other types of content, such as particular multimedia files or documents with particular keywords in them. Because DPI blocking examines all traffic to end users, it is also quite invasive of end user privacy.

The overall efficacy of DPI blocking varies widely depending both on the goals and the specific DPI tools being used. Generally, DPI tools are most effective in network management and security enforcement, and are not well-suited for policy-based blocking.

URL-Based Blocking

URL-based blocking is a very popular blocking method, and may occur both on the individual computer, or in a network device between the computer and the rest of the Internet. URL blocking works with web-based applications, and is not used for blocking non-web applications (such as VoIP). With URL blocking, a filter intercepts the flow of web (HTTP) traffic and checks the URL, which appears in the HTTP request, against a local database or on-line service. Based on the response, the URL filter will allow or block the connection to the web server requested.

Generally, URLs are managed by category (such as "sports sites") and an entire category is blocked, throttled, or allowed[5]. In the case of a national policy requiring URL blocking, the on-line service and blocking policy would likely be managed by the government. The URL filter can simply stop the traffic, or it can redirect the user to another web page, showing a policy statement or noting that the traffic was blocked. URL blocking in the network can be enforced by proxies, as well as firewalls and routers.

Sidebar:
Encryption, Proxies, and Blocking Challenges

Several of the techniques discussed in this paper, including Deep Packet Inspection (DPI)-based blocking and URL-based blocking, have a very real limitation: they must be able to see the traffic being evaluated. Web servers that offer encryption or users who add encryption to their communications (typically through application-specific encryption technology, such as TLS/SSL) cannot be reliably blocked by in-the-network devices. Many of the other techniques are also easily evaded when user have access to VPN technology that encrypts communications and hides the true destination and type of traffic. Although researchers and vendors have developed some ways of identifying some types of traffic through inference and analysis, these techniques often are simply guessing at what type of traffic they are seeing.

In recent research, 49% of US web traffic (by volume) was encrypted in February, 2016. (See: http://www.iisp.gatech.edu/sites/default/files/images/online_privacy_and_isps.pdf) This traffic would be effectively invisible to URL-based blocking and DPI tools that look at content, because the only visible information would be the domain name of the server hosting the information. To compensate for this "going dark," some network blocking uses active devices (called proxies) that intercept and decrypt the traffic between the user and the web server, breaking the end-to-end encryption model of TLS/SSL.

When proxies are used, these cause significant security and privacy concerns. By breaking the TLS/SSL model, the blocking party gains access to all encrypted data and can inadvertently enable third-parties to do the same. The proxy could also change the content. If the blocking party has control over the user's system (for example, a corporate-managed device would be highly controlled), the proxy may be very transparent. Generally, however, the presence of a proxy would be obvious to the end user, at least for encrypted (TLS/SSL) traffic (e.g. the user may get an alert that the certificate is not from a trusted authority). In addition, new industry and IETF standards (such as HTTP Strict Transport Security [RFC6797], HTTP Public Key Pinning [RFC 7469], and DANE [RFC 6698]) and new security features in modern Internet browsers make it more difficult to proxy (and decrypt) TLS/SSL traffic without the knowledge and cooperation of the end user.

Proxies installed for content blocking reasons may also introduce performance bottlenecks into the flow of network traffic, making services slow or unreliable.

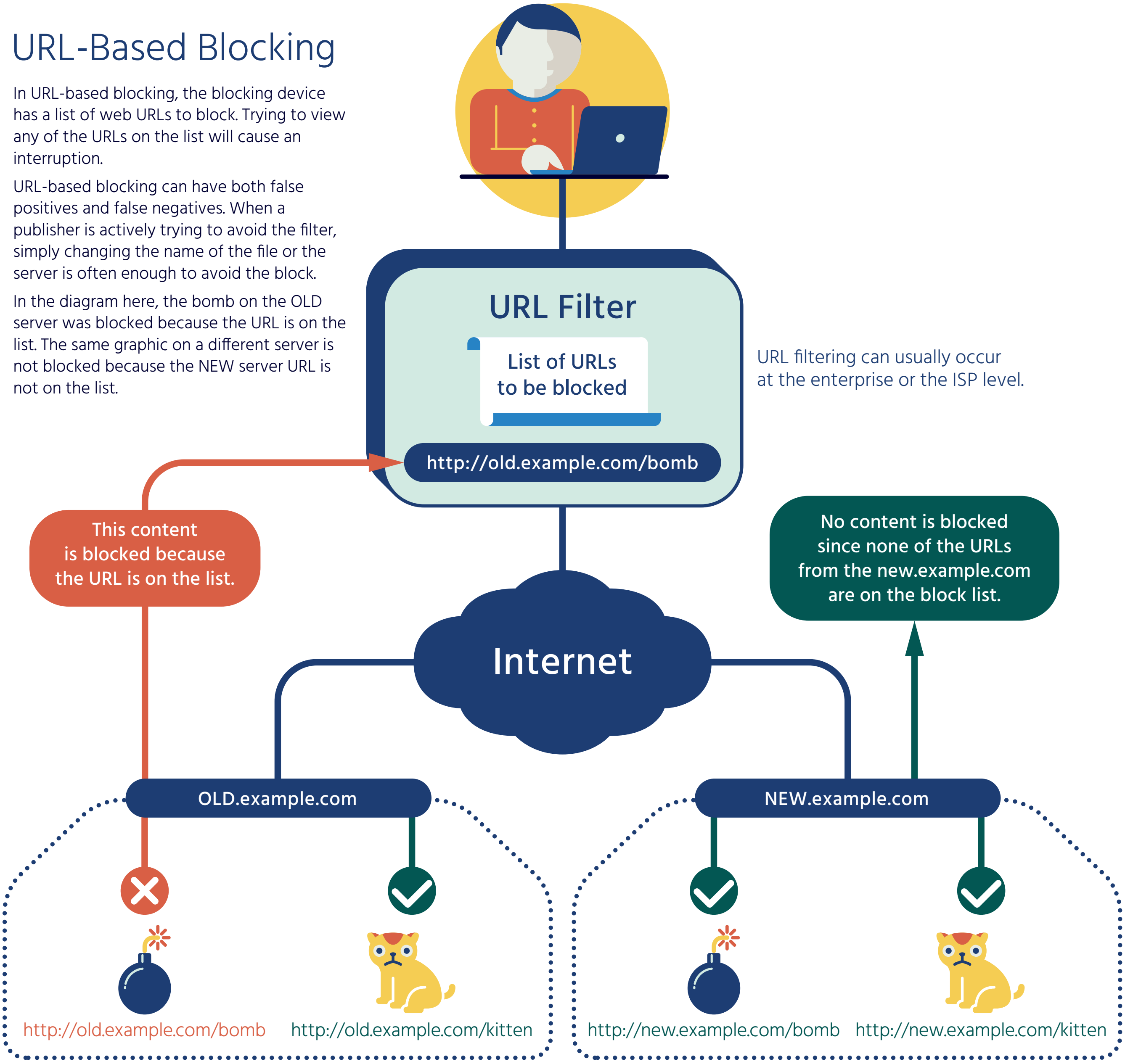
[5] URL filtering categories are established by security service providers and are often based on a combination of human analysis of web pages combined with some automated scanning of web page content. Most security service providers offer URL filtering databases for the purposes of managing corporate network traffic, but they can be used in other contexts, such as those discussed in this paper.

URL-Based Blocking

In URL-based blocking, the blocking device has a list of web URLs to block. Trying to view any of the URLs on the list will cause an interruption.

URL-based blocking can have both false positives and false negatives. When a publisher is actively trying to avoid the filter, simply changing the name of the file or the server is often enough to avoid the block.

In the diagram here, the bomb on the OLD server was blocked because the URL is on the list. The same graphic on a different server is not blocked because the NEW server URL is not on the list.


URL Filter
List of URLs to be blocked
http://old.example.com/bomb
This content is blocked because the URL is on the list.
Internet
No content is blocked since none of the URLs from the new.example.com are on the block list.
OLD.example.com
NEW.example.com
http://old.example.com/bomb
http://old.example.com/kitten
http://new.example.com/bomb
http://new.example.com/kitten

URL filtering can usually occur at the enterprise or the ISP level.

URL blocking requires the blocking party (such as the user's ISP) to have the ability to intercept and control traffic between the end-user and the Internet. URL blocking is usually expensive, because the filtering device generally has to be in-line between the user and the Internet, and thus requires a high level of resources to give acceptable performance.

URL blocking is generally considered to be very effective at identifying content that may be on different servers or services because the URL doesn't change even if the server changes IP addresses. In a few cases, URL blocking may fail to fully block the traffic when the URLs are very complicated or change frequently. This can happen because an information publisher has deliberately decided to actively evade URL filter blocking, or it can be a side effect of some advanced publishing systems such as those used for large on-line publications.

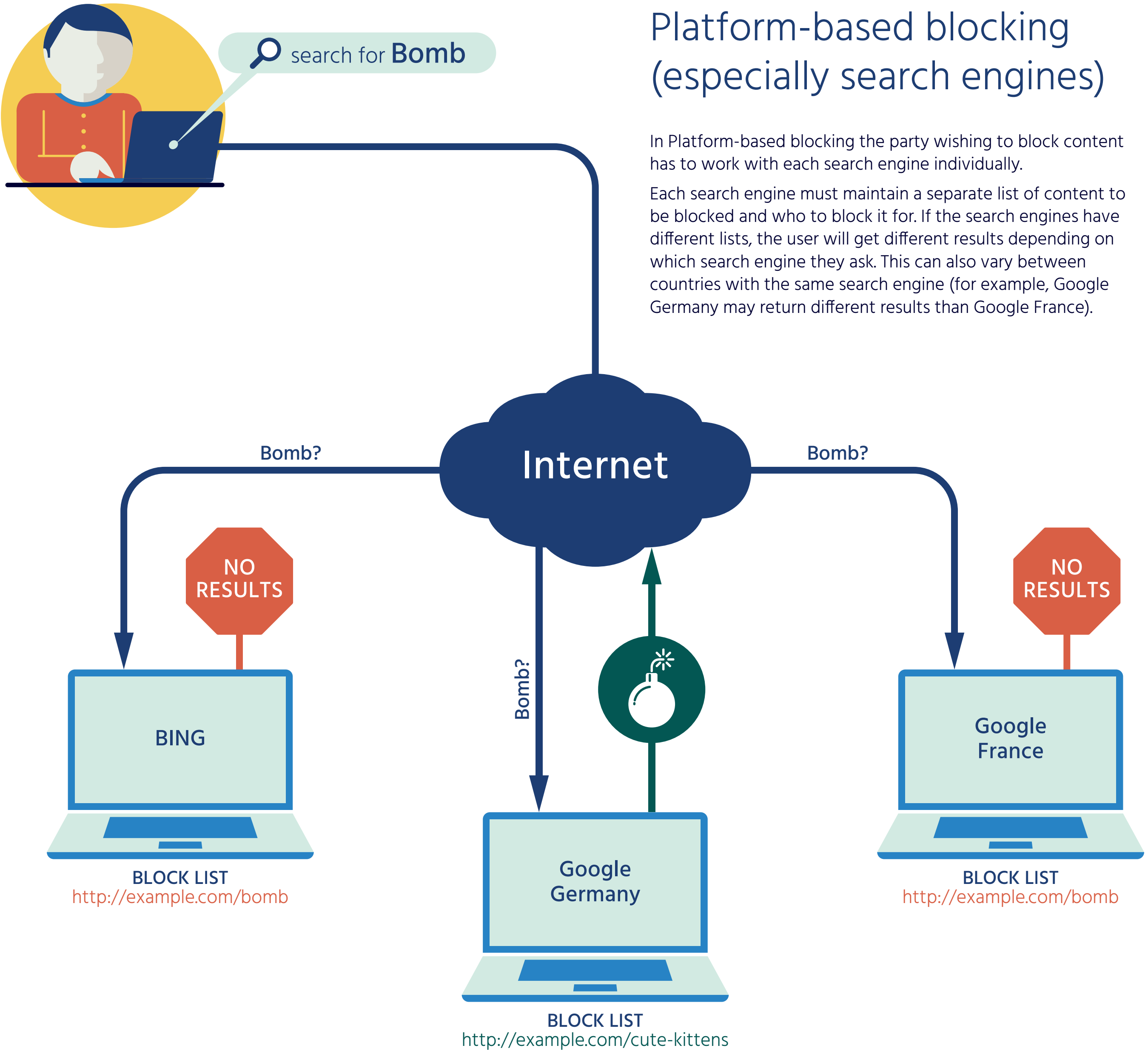
URL blocking usually is effective at high-level URLs, such as a particular web page, but is not as effective when deep links (such as individual bits of content within a web page) are considered. Depending on how the user navigated to the particular content, URL blocking may or may not be able to block all access—if the user has a "deep link" not covered by the URL filter, the content will be allowed. For example, the Playboy web site includes both playboy.com URLs, but also embedded content using the "playboy.tv" domain name. A URL filter that didn't also include "playboy.tv" URLs would not block the video content.

All types of URL blocking are highly dependent on the quality of the filter, and a poorly designed or overly broad filter may block unintended traffic or have other negative effects on the user experience, such as affecting the loading or formatting of web pages when some component is being blocked.

As with Deep Packet Inspection types of blocking, URL blocking requires some type of proxy to see the full URL when traffic is encrypted with HTTPS (TLS/SSL). See sidebar "Encryption, Proxies, and Blocking Challenges", page 15, for more information on the effects on end-user privacy. For encrypted traffic, URL blocking can only see the IP address of the server, and not the full URL, resulting in a much higher level of unintended blocking. Because proxies are expensive and intrusive to the user experience, URL blocking does not work well as a tool for policy-based blocking.

Platform-Based Blocking (Especially Search Engines)

In some cases, national authorities will work with major information service providers to block information within their geographic region without blocking the entire platform. The most common examples of platform filtering are through the major search engine providers and social media platforms. Recently, it has also been reported that mobile application stores (such as the Apple Store and Google Play) are working with national authorities to block downloads of specific applications in their country.



Platform-based blocking (especially search engines)

In Platform-based blocking the party wishing to block content has to work with each search engine individually.

Each search engine must maintain a separate list of content to be blocked and who to block it for. If the search engines have different lists, the user will get different results depending on which search engine they ask. This can also vary between countries with the same search engine (for example, Google Germany may return different results than Google France).

Platform-based blocking is a technique that requires the assistance of the platform owner, such as a search engine operator like Google or Microsoft. In this technique, queries from a particular set of Internet users to a search engine will receive a different set of results from the rest of the Internet—filtering out pointers to content that are, in some way, objectionable. In some cases the definition of what is to be blocked is based on local regulation and government requirements, but it may also be due to concerns by the search engine operator. For example, a search engine may block pointers to malware or content considered inappropriate according to its own terms of service.

Because search engine blocking requires the cooperation of the search engine provider, this limits its use to two very specific scenarios: country-level rules (blocking content based on country-specific or region-specific rules) and age-based rules (blocking material inappropriate for young people).

Search engine blocking only affects users who choose a particular search engine, and only when the users are identified as being from a particular set with filter rules. In age-based blocking, such as SafeSearch[6] (offered by major search engines and content providers), an explicit opt-in is required.

Since search engine blocking only filters out pointers to content, and not actual content, it is an extremely ineffective technique, and can have the unintended consequence of drawing increased attention to the blocked content. The presence of multiple search engines, as well as alternative methods of finding content, make this type of blocking very difficult to enforce.

Although search engine blocking seems like it does very little towards blocking content, the technique is extremely popular at the national level, and governments around the world are known to demand that major search engines implement filters according to their regulations, such as infringement of copyright or particular types of speech prohibited by national law. For example, Google reported in 2015 that it had received 8,398 requests from 74 national courts to remove 36,834 results from its search results[7]. Copyright infringement requests made by individuals are also very popular: in June 2016, Google reported that 6,937 copyright owners had requested over 86 million search results to be removed from Google results during that month[8].

Search engine blocking is also used by individuals as part of the so-called "right to be forgotten," with over a million URLs globally requested to be blocked in the last two years (May 2014 to June 2016).

Sidebar:
Blocking On Other Platforms

While search engine blocking is the most common type of platform blocking, other platforms with enormous users communities are often considered for this technique. Common examples of these types of platforms include Facebook (which has over 1.5 billion active users each month) and YouTube (with over a billion unique users). Attempts to use network-based or URL-based techniques to block individual content elements, such as a particular news article, are very difficult. Because they don't want to be seen as blocking all of Facebook (for example), national authorities have proposed working with major platform providers to filter out specific types of content they deem illegal.

Very little is known about the effectiveness, scope, or side effects of other kinds of platform blocking, as this technique has not been widely and reliably observed on platforms other than search engines. While the major platforms, such as Facebook, YouTube, and Twitter, will universally block certain types of content (such as malware and pornographic material) and provide customized content feeds to their users, information on national-specific blockages is not available.

[6] SafeSearch is a feature of major search engines, including Google Search, Microsoft Bing, and Yahoo!, that blocks results containing "inappropriate or explicit images" from search results.

[7] https://www.google.com/transparencyreport/removals/government/?hl=en

[8] https://www.google.com/transparencyreport/removals/copyright/?hl=en

DNS-Based Content Blocking

DNS-based content blocking avoids one of the problems with other techniques: the cost and performance impact of filtering all network traffic. Instead, DNS-based content blocking focuses on examining and controlling DNS queries.

With DNS-based content blocking, a specialized DNS resolver (see Sidebar: DNS Overview) has two functions: in addition to performing DNS lookups, the resolver checks names against a block list. When a user's computer tries to use a blocked name, the special server returns incorrect information, such as the IP address of a server displaying a notice that the content has been blocked. Or, the server may claim that the name does not exist. The effect is that the user is impeded from easy access to content using certain domain names.

As with all network-based blocking, DNS-based content blocking is only effective when the organization doing the blocking has complete control over the network connection of the end user. If the user can select a different connection, or use a different set of DNS servers, the technique does not affect them. For example, when Turkey blocked some DNS queries in 2012, users changed their systems to use Google's popular public DNS servers and avoid the blockage. Turkish authorities responded by hijacking all traffic to the Google DNS service, which caused significant collateral damage. DNS-based content blocking requires firewalls or other devices that can intercept and redirect all DNS queries to the specialized blocking-aware DNS servers or it will not be very effective.

The effectiveness of DNS-based content blocking is similar to IP-based blocking. It is slightly more effective because the list of domain names is easier to keep updated and is more accurate than a list of IP addresses for most types of content blocking. However, it is slightly less effective because changing domain names is simpler than changing IP addresses, which makes it easier for both end users and information publishers to evade this type of block.

An alternative form of DNS-based content blocking is when domain names are taken down, or removed from the DNS altogether. This method is more difficult to circumvent and the collateral damage is somewhat limited. In many cases it depends on the efficacy of cross-border cooperation, when a request or a court order comes from a jurisdiction different from where the registry or registrar operates.

DNS-based content blocking has similar drawbacks to blocking based on IP address: both prohibited and non-prohibited content may be on the same server using the same name (such as "facebook.com"), yet all would be blocked. In addition, the modification of DNS responses may cause other technical problems that interrupt other valid services[9].

DNS-based content blocking also depends on the user playing by the normal rules of the Internet and using the standard DNS service to translate names to IP addresses. Users who have complete control over their own computers and some technical expertise can reconfigure them to evade the standard DNS service and use alternatives, or simply have a list of name-to-address translations stored locally.

Sidebar:
DNS Overview

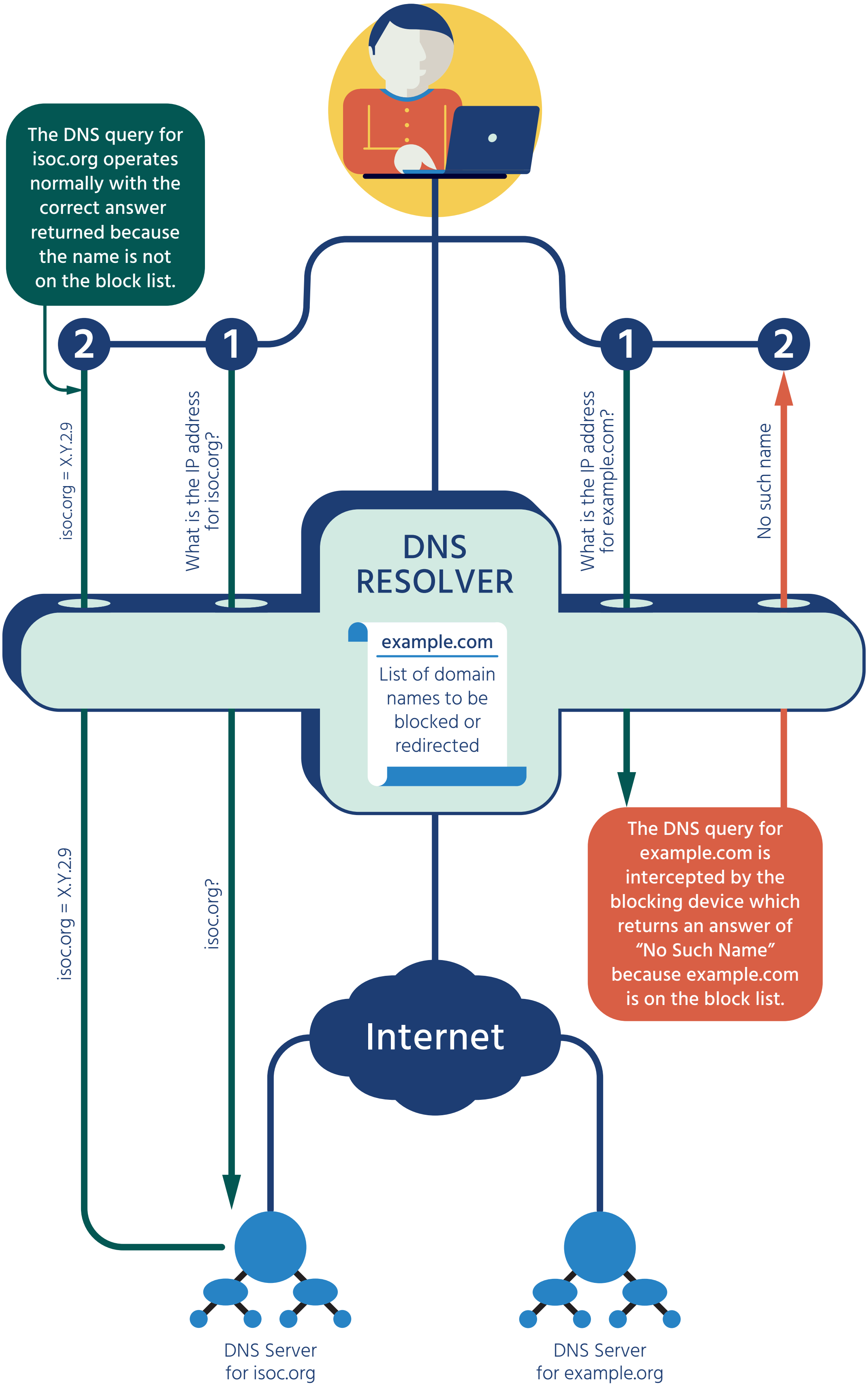
The DNS is a conceptually simple system that allows a string of labels (such as "www," "isoc," and "org") separated by dots (the domain name) to be looked up in a database distributed across multiple DNS servers. The domain name lookup results in an answer (for example, an IP address or a website), or the answer that the name does not exist.

The most common type of DNS lookup is for IP (Internet Protocol) addresses. This is the type of lookup that occurs each time a user types a URL into a web browser, for example. Normally, the individual application (such as the web browser) does not perform the full lookup, which involves several steps. Instead, the application uses an intermediate system called a "resolver" (because it resolves DNS name lookups), which navigates the DNS distributed database to retrieve the information requested.

In DNS-based content blocking, the normal operation of the resolver is changed.

[9] Readers interested in more details may wish to refer to Internet Society's "Perspectives on DNS Filtering" report at https://www.internetsociety.org/internet-society-perspectives-domain-name-system-dns-filtering-0

DNS-Based Blocking


The DNS query for isoc.org operates normally with the correct answer returned because the name is not on the block list.
2
1
1
2
isoc.org = X.Y.2.9
What is the IP address for isoc.org?
What is the IP address for example.com?
No such name
DNS RESOLVER
example.com
List of domain names to be blocked or redirected
The DNS query for example.com is intercepted by the blocking device which returns an answer of "No Such Name" because example.com is on the block list.
isoc.org = X.Y.2.9
isoc.org?
Internet
DNS Server for isoc.org
DNS Server for example.org

In DNS-based blocking, the blocking device has a list of DNS names to block.

Because most Internet connections require a translation from a DNS name to an IP address, blocking the query and returning a false answer can discourage users from trying to retrieve blocked content or connect to blocked services by other means (e.g. directly typing the IP address).

Content Blocking Summarized

Internet Content Blocking Techniques

	IP and Protocol-Based Blocking	Deep Packet Inspection-Based Blocking	URL-Based Blocking	Platform-Based Blocking (especially search engines)	DNS-Based Blocking
Overview	A device is inserted in the network that blocks based on IP address and/or application (e.g., VPN)	A device is inserted in the network that blocks based on keywords and/or other content (filename, for example)	A device is inserted in the network that intercepts web requests and looks up URLs against a block list	Working with application providers (such as search engines), content is modified according to local requirements	At the network or ISP level, DNS traffic is funneled to a modified DNS server that can block lookups of certain domain names
Is it effective?	Because IP addresses are easily changed and content easily moved, **this technique works poorly.** This only works well when the information publisher is not actively working to evade the block.	Where the blocked information is easily characterized, this is very effective. For general blocking (e.g., "block adult content") or in the face of encryption, **the technique is very ineffective**	This is a common technique that **works well when blocking access to entire categories** of information. New pages and smaller sites slip through easily, as do encrypted web servers.	Because there is no monopoly in search engines (for example) and consumer preferences are constantly changing, **this type of blocking is largely cosmetic and works poorly.**	DNS blocking is easily evaded both by content publishers and end users. DNS blocking is only effective when each name has a very small amount of content, and all that content should be blocked. **Technical challenges, over-blocking, and ease of evasion make this an ineffective technique.**
Who is affected?	Anyone who is "behind" the device is affected.	Anyone who is "behind" the device is affected.	Users "behind" the device, and for whom the device can intercept and evaluate web traffic.	Users of the search engine which has installed the block	Users of the modified DNS server. This can be enforced at the network or service provider level.
How specific is it?	**Affects all content on a server, whether illegal or not.** This works even when the data are encrypted.	**Affects only content which matches blocking rules.** Requires proxies to work with encrypted web pages.	**Affects individual web pages and web elements.** Requires proxies to work with encrypted web pages.	**Affects individual web pages and elements.** Usually done at the individual URL level.	**Affects all content served by a domain name, whether illegal or not.** Cannot be effectively used to distribute content.
What type of technique is this?	Blocks content	Blocks content	Blocks content	Discourages and frustrates access	Discourages and frustrates access
How much collateral damage is caused?	Any targeting of larger servers has a huge false positive rate, blocking both illegal and legal content.	Depending on the quality of the blocking rules, the false positive rate can range from very low to quite high. Writing good rules is difficult.	Most URL filtering is based on commercial services that categorize traffic. For mainstream blocks, this can be quite specific, but for special purpose blocks, the error rate is quite high.	The false positive rate is considered to be low, because each page block is requested individually. The problem of non-legitimate requests causes some inappropriate information to be blockage.	Any targeting of domain names used by larger servers has a huge false positive rate, blocking both illegal and legal content. Ineffective when CDNs are used (or causes an extremely high level of false positives).
What are common ways to evade it?	Publishers can change IP addresses, migrate content, or use Content Delivery Networks (CDNs) to evade. VPN users evade by hiding IP addresses.	Multiple layers of encryption effectively evade this type of blocking. When the filtering rules are poorly written, small changes in text can easily bypass blocks.	Multiple layers of encryption effectively evade this type of blocking. Use of non-standard application layer is often an effective evasion technique.	Users can choose alternative platforms, such as a different search engine, very easily.	Users can avoid using DNS lookups using local facilities, or can send their queries to an un-modified public server (typically though a VPN).
Are there side-effects or technical issues?	Maintaining long IP address lists is difficult and error-prone, and requires significant resources. Network devices doing this type of blocking are typically speedy, so performance issues are not common.	Content-aware filtering has significant performance costs and is not practical in many environments (without enormous resources). When proxies are used, security can be severely compromised.	URL filtering can cause performance problems, decreasing overall speed and reliability. When proxies are used, security can be severely compromised.	Many search engines report on "suppressed" information, which itself creates a trail to the content.	DNS security is compromised when a modified server is deployed.

Conclusion

Understanding the different blocking techniques, their effects and side effects, is important both for policy makers considering the use of such measures and for Internet advocates and others wishing to influence content blocking practices.

All blocking techniques are prone to two main drawbacks:

1. **They do not solve the problem**

   Blocking techniques do not remove content from the Internet, nor do they stop the illegal activity or prosecute culprits; they simply put a curtain in front of the content. The underlying content remains in place.

2. **They inflict collateral damage**

   Every blocking technique suffers from over-blocking and under-blocking: blocking more than is intended and, at the same time, less than intended. They also cause other damage to the Internet by putting users at risk (as they attempt to evade blocks), reducing transparency and trust in the Internet, driving services underground, and intruding on user privacy. These are costs that must be considered at the same time that blocking is discussed.

Sidebar:
Circumventing Content Blocking

Policy makers should keep in mind an important point when considering blocking Internet content: all of the technical blocking techniques can be bypassed by a sufficiently motivated user. In many cases, only minimal work is needed to evade the block.

If traffic to a host or domain name is blocked, tools such as VPNs can be used to hide the traffic. If the traffic content is being inspected, then it can be encrypted so that it does not trigger the block. If the content is taken down, other users may reload it on other servers. If the domain name used is removed, end users can still access the host if they know the IP address, or a new domain name can be selected as a replacement. If a search engine removes results, there are always other search engines.

End users are not the only ones who can and do evade blocks. Information publishers also have many approaches to duck various blocking techniques. If a publisher works hard enough to distribute and disseminate content, no block technique can stop them.

Recommendations

The Internet Society believes the most appropriate way to counteract illegal content and activities on the Internet is to attack them at their source. Using filters to block access to online content is inefficient, likely to be ineffective, and is prone to generate collateral damage affecting innocent Internet users.

We suggest two main strategies for policy makers concerned about illegal content on the Internet:

1. **Attack the issue at the source:** The least damaging approach for the Internet is to "attack" illegal content and activities at their source. Removing illegal content from its source, and undertaking enforcement against the perpetrators avoids the negative effects of blocking, and is more effective at removing illegal content[10]. Cooperation across jurisdictions and stakeholders is a prerequisite for success, as illegal content online extends beyond national borders and national law.

[10] When the national authority is in the same jurisdiction as the consumer of content, removing illegal content at the source seems an easy way around the complexities and overhead of cross- border actions. We acknowledge that removing the content at the source is challenging in the context of a cross-border Internet, where providers and consumers of content may be located in different jurisdictions, subject to different laws. Yet, we consider this should not be a reason not to identify more efficient solutions that do not harm the Internet.

2. **Prioritize and use alternative approaches:** Depending on circumstances, different approaches can be quite effective. For example

   - Effective cooperation among service providers, law enforcement and national authorities may provide additional means to help the victims of illegal content, and to take enforcement action against the perpetrators[11].
   - Creating an environment of trust where users receive information on what is legal and what is not can improve self-policing.
   - In some cases (e.g. parental control), empowering user to use filters on their own devices, with their consent, can be effective and least damaging to the Internet.
   - On a voluntary or legal basis, some websites (e.g. gambling websites) could use geolocation to prevent access from countries where their services are not allowed.

Minimizing Negative Effects

All content blocking techniques have serious deficiencies, especially in the context of blocking based on public policy considerations. All techniques behave poorly and can be evaded. For this reason, and the reasons stated before, we advise against content blocking.

Nonetheless, these techniques are still used. Recognizing this reality, we offer the following specific guidelines to lessen the negative impact:

a. **Rule out all non-blocking options:** First, and foremost, exhaust all practical options to have content addressed at the source, or any other alternative means to blocking. Blocking content should not be pursued simply because it is easier.

b. **Be transparent:** There should be transparency about the blocking as well as the underlying objective and policies. National authorities should make sure that affected users have the opportunity to raise concerns about negative impacts on their rights, interests and opportunities.

c. **Consider your responsibility towards the Internet:** The blocking party should be aware that they share a responsibility towards the system as a whole to not harm the stability, security and resilience of the Internet. Blocking techniques adversely impact the way the Internet is collectively managed and functions. Sometimes the damage is direct, and sometimes, it is indirect. For instance, users working around the block may cause problems or threaten their personal security.

e. **Think globally, act locally:** Local blocking and filtering can have global effects. But generally, blocking content as locally as possible will minimize the global impact. Ideally, blocking at the user's end-point is most efficacious and minimizes collateral damage.

f. **Involve stakeholders:** Policy development and implementation should involve a broad set of stakeholders including technological, economic, consumer rights and other specialists to ensure the appropriate steps are taken to minimize negative side-effects.

g. **Keep it temporary:** Any blocking measures should be temporary. They should be removed as soon as the reason for blocking ceases to exist. It is quite common for illegal content to be moved to evade blocking measures, yet the measures often remain in place long after the content has moved.

h. **Follow due legal process:** Any blocking order of unlawful content must be supported by law, independently reviewed, and narrowly targeted to achieve a legitimate aim. The least restrictive means available to deal with illegal activity should be prioritized. Internet Service Providers or other Internet intermediaries should not become de-facto law enforcement agents: they should not be required to determine when conduct or content is illegal.

[11] For example, partnerships with the finance industry can be used to identify and limit illegal transactions.

Glossary

CDN A content delivery network or content distribution network (CDN) is a globally distributed network of proxy servers deployed in multiple data centers. The goal of a CDN is to serve content to end-users with high availability and high performance. CDNs serve a large fraction of the Internet content today, including web objects (text, graphics and scripts), downloadable objects (media files, software, documents), applications (e-commerce, portals), live streaming media, on-demand streaming media, and social networks. (https://en.wikipedia.org/wiki/Content_delivery_network)

Content In the context of this paper, we use "content" generally to describe information found on the Internet. This content might be a full document or just a paragraph of some text, an image, a video, or even just audio (such as a podcast). Content could be on web pages viewed in a browser, or it could be accessible through more specialized tools such as a custom application.

DNS The Domain Name System (DNS) is a hierarchical decentralized naming system for computers, services, or other resources connected to the Internet or a private network. It associates various information with domain names assigned to each of the participating entities. Most prominently, it translates more readily memorized domain names to the numerical IP addresses needed for locating and identifying computer services and devices with the underlying network protocols. By providing a worldwide, distributed directory service, the Domain Name System is an essential component of the functionality of the Internet, that has been in use since 1985. (https://en.wikipedia.org/wiki/Domain_Name_System)

DPI Deep Packet Inspection (DPI) is a form of computer network packet filtering that examines the data part (and possibly also the header) of a packet as it passes an inspection point, searching for protocol non-compliance, viruses, spam, intrusions, or defined criteria to decide whether the packet may pass or if it needs to be treated in another way, including discarding the packet. (https://en.wikipedia.org/wiki/Deep_packet_inspection)

Illegal In the context of this paper, we use "illegal" to describe content that is prohibited in a national context no matter what the reason. This could be content that is illegal because it is a copyright violation (or some other type of intellectual property), such as a pirated movie. It could be content that is illegal because it is objectionable for moral reasons, such as obscenity or child pornography. It could be content that it is illegal because national authorities wish to suppress it or find it offensive, such as a cartoon depicting the president of the country in an unfavorable way. Content that is illegal in one jurisdiction may be completely legal in another. Content that is illegal in one context (such as indecent comedy, when viewed by children) may be completely legal in another (such as when viewed by adults), even within the same jurisdiction.

IP address An IP address (abbreviation of Internet Protocol address) is an identifier assigned to each computer and other devices (e.g., printer, router, mobile device, etc.) connected to the Internet. It is used to locate and identify the node in communications with other nodes on the network. (https://en.wikipedia.org/wiki/IP_address)

False Negative A false negative occurs when content is not blocked, but it should have been. For example, if illegal pharmacies are being blocked, a brand new illegal pharmacy might not be blocked if the server had not been added to the block list yet. This would be called a false negative.

False Positive A false positive occurs when some content is blocked which was not intended to be blocked. For example, if pornography is being blocked, information about cooking of chicken breasts might be blocked if the block used a poorly constructed keyword search. This would be considered a false positive.

TLS/SSL Transport Layer Security (TLS) and its predecessor, Secure Sockets Layer (SSL), both frequently referred to as "SSL", are cryptographic protocols that provide communications security over a computer network. Several versions of the protocols find widespread use in applications such as web browsing, email, Internet faxing, instant messaging, and voice-over-IP (VoIP). Websites use TLS to secure all communications between their servers and web browsers. The Transport Layer Security protocol aims primarily to provide privacy and data integrity between two communicating computer applications.
(https://en.wikipedia.org/wiki/Transport_Layer_Security)

URL Uniform Resource Locator (URL), commonly informally termed a web address, is a reference to a web resource that specifies its location in the network and a mechanism for retrieving it. URLs occur most commonly to reference web pages (https), but are also used for file transfer (ftp), email (mailto), database access (JDBC), and many other applications. Most web browsers display the URL of a web page above the page in an address bar. A typical URL could have the form https://www.example.com/index.html, which indicates a protocol (https), a hostname (www.example.com), and a file name (index.html).
(https://en.wikipedia.org/wiki/Uniform_Resource_Locator)

VPN A virtual private network (VPN) extends a private network across a public network, such as the Internet. It enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network. Applications running across the VPN may therefore benefit from the functionality, security, and management of the private network.
(https://en.wikipedia.org/wiki/Virtual_private_network)

For Further Reading

The following publications may be of interest to readers looking for additional information on this topic.

Internet Engineering Task Force Technical Documents

"A Survey of Worldwide Censorship Techniques" (IETF draft draft-hall-censorship-tech-04)
https://tools.ietf.org/html/draft-hall-censorship-tech-04

"Technical Considerations for Internet Service Blocking and Filtering" (RFC 7754)
https://tools.ietf.org/html/rfc7754

Policy, Survey, and Background Documents

"Filtering, blocking and take-down of illegal content on the Internet", Council of Europe, 2015.
http://www.coe.int/en/web/freedom-expression/study-filtering-blocking-and-take-down-of-illegal-content-on-the-internet

"Freedom of Expression Unfiltered: How blocking and filtering affect free speech" Article 19, 2016.
https://www.article19.org/data/files/medialibrary/38586/Blocking_and_filtering_final.pdf

"Freedom on the Net 2016", Freedom House, November 2016.
https://freedomhouse.org/report/freedom-net/freedom-net-2016

"Internet Society Perspectives on Domain Name System (DNS) Filtering", Internet Society, 2012.
https://www.internetsociety.org/sites/default/files/Perspectives%20on%20Domain%20Name%20System%20Filtering-en.pdf

"Network Neutrality", Internet Society, 2015.
http://www.internetsociety.org/sites/default/files/ISOC-PolicyBrief-NetworkNeutrality-20151030.pdf

"Perspectives on Policy Responses to Online Copyright Infringement" Internet Society, 2011.
https://www.internetsociety.org/sites/default/files/bp-copyrightpolicy-20110220-en-1.pdf

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