[[1]](#footnote-1)

Enlighten DarkWeb Markets with Data Mining

First A. Author, *Fellow, IEEE*, Second B. Author, and Third C. Author, Jr., Member, IEEE

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# INTRODUCTION

P

OLICE forces have been fighting strenuously against illegal websites (e.g. Megaupload [1]), but new ones resurface or re-migrate frequently [2]. This is also happening on the dark web. As a matter of fact, plenty of marketplaces have been shut down, however there are still a lot of them online at the time of this research [3]. On top of that, currently, we don't really know in detail how these websites operate.

This paper presents a research carried out between June and September 2017 on the largest web market at the time (especially for drugs) on Internet, AlphaBay. This web market has caught the attention of governmental agencies since two teenagers aged of 13 and 18 died after overdosing on a powerful synthetic opioid. It has been shut down on July 2017, at the same time of Hansa, as a part of a law enforcement operation by the Federal Bureau of Investigation, the Drugs Enforcement Administration and European law enforcement agencies acting through Europol. [4] [5]

According to US Attorney General Jeff Sessions the aim of this action was to caution criminals from thinking that they could evade prosecution by using the dark web. Looking at previous large shut down marketplaces it is widely believed that other web markets will take the place of AlphaBay. By the way, the popularity of AlphaBay can be explained by the shutdown of Silk Road 2.0 on 2013 since it has been launched on September 2014.

This paper reports on the last weeks of life of Alphabay. Its nature, its different countries of origin, its main sellers, its predominance of items will be analyzed.

# Method

[AB part].

During a first phase "Basic Statistics" will be carried out on the Database, in order to discover the web market and to point out its trends. Then, experimental results of data mining techniques will be discussed.

# Technical Implementation

## Software Stack

There is a number of technologies and programming languages that can be used for Data Analysis. The 3 main programming languages for this kind of research are Python, SAS and R. Since we would like to use open-source languages, we exclude SAS and eventually chose R. [6]

Beside standard libraries, we have made extensive use of:

### units: Unit library including solution for conversion.

### rpart: Package that contains a wide library for decision tree method.

### arules: Used for association rules.

### e1071: Bayesian Naive implementation library.

### bnlearn: library including solution for Bayesian network creation and visualization.

We have used RStudio for implementing code. As for publishing the results, we have used R Notebooks [7].

## Code Repository

All the code is publicly available in the Github project \*"Data Mining - Dark Web Market"\*. The repository is accessible from the following link: <https://github.com/SimonDele/Data-Ming-Dark-Web-Market>

You can also find the whole list of packages used in the GitHub repository.

## Detailed Diagram

This is the representation of the technical implementation taking place during this project:

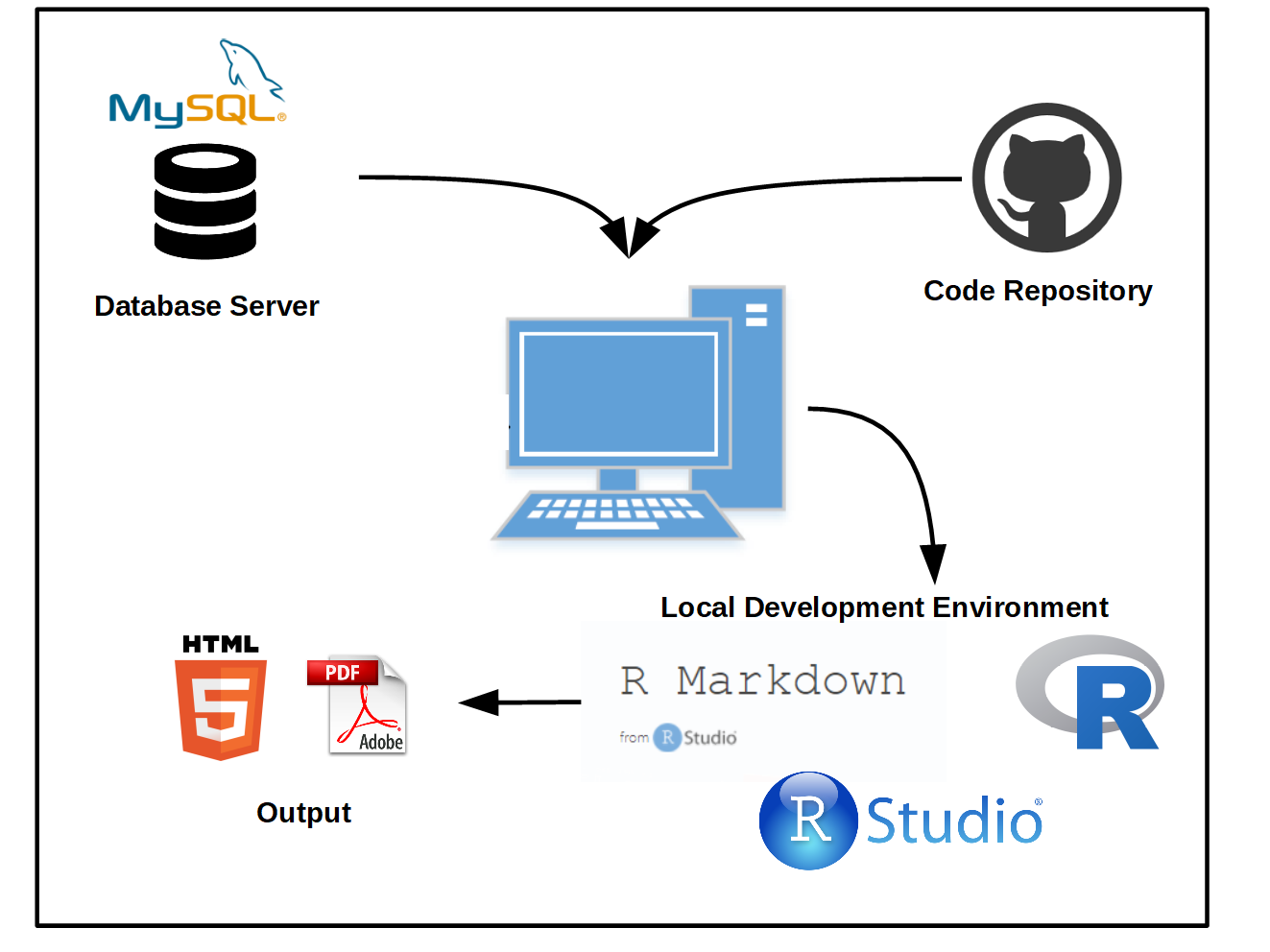


Fig. Technical implementation

# Data Retrieval

Here is what the Database looks like : ??????

For each product we have collected and analysed ad title, description, price (in USD), url, seller, payment, origin, destination, category, collection timestamp, date of posting and number of products sold.

[AB to refine]The data represents approximately \*1/10\* of the Web Market, but gives a pretty good representation since the uploaded ads were fairly distributed.

Thus, the first step was to clean the data and to make it readable in a computer way. This is our pipelines :

- Removing special characters, switching in lowercase.

- Finding in the title or description of the ads the amount (number and mass) of the product.

- Calculating the price of one unit of one dose (1 gram) each time.

# Alphabay Market

As it has been said in the [Introduction][- Introduction], AlphaBay, due to its popularity, drew the police forces attentions. As a matter of fact its reputation can be reflected by looking at Google search statistics with the keywords alphabay and dream market between January 2015 until June 2017 @GTComp.

On this graph, AlphaBay is in blue and Dream Market is in red, which is an other Dark Web Market still operating. AlphaBay has become more and more popular since the demise of Agora, and before being shut down, it was the most popular dark web market @AlphaBig .

Let's now try to look at the evolution of the market with the collected data on \*AlphaBay\*. Here you can see the number of ads posted per month from \*January 2015\* until \*June 2017\*.

The overall appearance and the growing popularity can be again pointed out with this graph. Between 2015 and 2016, there was a significant jump, the amount of ads rose from `r Number\_of\_Ads[1]` up to `r Number\_of\_Ads[2]`. Nevertheless the most surprising thing is that the number of ads that have been posted during the six first months of 2017 (before the closing) is `r Number\_of\_Ads[3]` which is almost the same that in the whole 2016.

In order to see how the market would have looked like in the end of 2017 a prediction also has been added on this graph. Therefore, according to prognoses, the amount of ads would have reached a pick of 5,000 ads by the end of year.



## Figure tt

# Basic Statistics

## General Distribution

As it has been said before, basic statistics have been first realized. Let's see the general distribution and trend of the market.

### Global view of ads distribution

This bar-chart represents the 10 main countries in the world regarding the number of ads. As we can see, United States are the biggest dealer far ahead of the rest. Their number of ads is more than twice as the number of the second one, United Kingdom.

Moreover, it is noticeable that most of these countries have strong economies. Five of the top 10 countries belong to the Group of Seven (G7), only Japan and Italy are not present. And other ones are also located in powerful areas where a lot of trade are made with other countries.

Furthermore it is worth pointing out that the first four countries are exactly the ones where the word "AlphaBay"\* is the most researched on Google @GTWorld !

### Distribution of ads per category

There are 12 main categories in this web marketplace. \*"Drugs and Chemicals"\* group is the largest one, representing `r rate[1]` % of the global market.

It is also worth noting that the second most popular category is \*"Fraud"\*, that is to say all the ads regarding impersonation, deception papers and accounts. It represents `r rate[2]` % of the market.

Eventually, all other items (digital product, weapons, jewelry ...) represent a small rate of the marketplace.

# Drug Market

AlphaBay core focus is clearly on Drugs (cf. Figure `r DrugsFig`). The following list outlines the different types of graphics published in IEEE journals. They are categorized based on their construction, and use of color / shades of gray:

TABLE I

Units for Magnetic Properties

|  |  |  |
| --- | --- | --- |
| Symbol | Quantity | Conversion from Gaussian and  CGS EMU to SI a |
| Φ | magnetic flux | 1 Mx → 10−8 Wb = 10−8 V·s |
| *B* | magnetic flux density,  magnetic induction | 1 G → 10−4 T = 10−4 Wb/m2 |
| *H* | magnetic field strength | 1 Oe → 103/(4π) A/m |
| *m* | magnetic moment | 1 erg/G = 1 emu  → 10−3 A·m2 = 10−3 J/T |
| *M* | magnetization | 1 erg/(G·cm3) = 1 emu/cm3  → 103 A/m |
| 4π*M* | magnetization | 1 G → 103/(4π) A/m |
| σ | specific magnetization | 1 erg/(G·g) = 1 emu/g → 1 A·m2/kg |
| *j* | magnetic dipole  moment | 1 erg/G = 1 emu  → 4π × 10−10 Wb·m |
| *J* | magnetic polarization | 1 erg/(G·cm3) = 1 emu/cm3  → 4π × 10−4 T |
| χ*,* κ | susceptibility | 1 → 4π |
| χρ | mass susceptibility | 1 cm3/g → 4π × 10−3 m3/kg |
| μ | permeability | 1 → 4π × 10−7 H/m  = 4π × 10−7 Wb/(A·m) |
| μr | relative permeability | μ → μr |
| *w, W* | energy density | 1 erg/cm3 → 10−1 J/m3 |
| *N, D* | demagnetizing factor | 1 → 1/(4π) |

Vertical lines are optional in tables. Statements that serve as captions for the entire table do not need footnote letters.

aGaussian units are the same as cg emu for magnetostatics; Mx = maxwell, G = gauss, Oe = oersted; Wb = weber, V = volt, s = second, T = tesla, m = meter, A = ampere, J = joule, kg = kilogram, H = henry.

### *Color/Grayscale figures*

### Figures that are meant to appear in color, or shades of black/gray. Such figures may include photographs, illustrations, multicolor graphs, and flowcharts.

### *Line Art figures*

### Figures that are composed of only black lines and shapes. These figures should have no shades or half-tones of gray, only black and white.

### *Author photos*

### Head and shoulders shots of authors that appear at the end of our papers.

### *Tables* Data charts which are typically black and white, but sometimes include color.

## Multipart figures

Figures compiled of more than one sub-figure presented side-by-side, or stacked. If a multipart figure is made up of multiple figure types (one part is lineart, and another is grayscale or color) the figure should meet the stricter guidelines.

## File Formats For Graphics

Format and save your graphics using a suitable graphics processing program that will allow you to create the images as PostScript (PS), Encapsulated PostScript (.EPS), Tagged Image File Format (.TIFF), Portable Document Format (.PDF), or Portable Network Graphics (.PNG) sizes them, and adjusts the resolution settings. If you created your source files in one of the following programs you will be able to submit the graphics without converting to a PS, EPS, TIFF, PDF, or PNG file: Microsoft Word, Microsoft PowerPoint, or Microsoft Excel. Though it is not required, it is strongly recommended that these files be saved in PDF format rather than DOC, XLS, or PPT. Doing so will protect your figures from common font and arrow stroke issues that occur when working on the files across multiple platforms. When submitting your final paper, your graphics should all be submitted individually in one of these formats along with the manuscript.

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There is currently one publication with column measurements that do not coincide with those listed above. Proceedings of the IEEE has a column measurement of 3.25 inches (82.5 millimeters / 19.5 picas).

The final printed size of author photographs is exactly   
1 inch wide by 1.25 inches tall (25.4 millimeters x 31.75 millimeters / 6 picas x 7.5 picas). Author photos printed in editorials measure 1.59 inches wide by 2 inches tall (40 millimeters x 50 millimeters / 9.5 picas x 12 picas).

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Figure axis labels are often a source of confusion. Use words rather than symbols. As an example, write the quantity “Magnetization,” or “Magnetization *M*,” not just “*M*.” Put units in parentheses. Do not label axes only with units. As in Fig. 1, for example, write “Magnetization (A/m)” or “Magnetization (Am−1),” not just “A/m.” Do not label axes with a ratio of quantities and units. For example, write “Temperature (K),” not “Temperature/K.”

Multipliers can be especially confusing. Write “Magnetization (kA/m)” or “Magnetization (103 A/m).” Do not write “Magnetization (A/m) × 1000” because the reader would not know whether the top axis label in Fig. 1 meant 16000 A/m or 0.016 A/m. Figure labels should be legible, approximately 8 to 10 point type.

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Appendix

Appendixes, if needed, appear before the acknowledgment.

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5. Papers that describe ongoing work or announce the latest technical achievement, which are suitable for presentation at a professional conference, may not be appropriate for publication.

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J. K. Author, “Title of chapter in the book,” in *Title of His Published Book, x*th ed. City of Publisher, (only U.S. State), Country: Abbrev. of Publisher, year, ch. *x*, sec. *x*, pp. *xxx–xxx.*

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1. G. O. Young, “Synthetic structure of industrial plastics,” in *Plastics,* 2nd ed., vol. 3, J. Peters, Ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15–64.
2. W.-K. Chen, *Linear Networks and Systems.* Belmont, CA, USA: Wadsworth, 1993, pp. 123–135.

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2. E. P. Wigner, “Theory of traveling-wave optical laser,”   
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   vol. 134, pp. A635–A646, Dec. 1965.
3. E. H. Miller, “A note on reflector arrays,” *IEEE Trans. Antennas Propagat*., to be published.

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J. K. Author, “Title of report,” Abbrev. Name of Co., City of Co., Abbrev. State, Country, Rep. *xxx*, year.

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1. E. E. Reber, R. L. Michell, and C. J. Carter, “Oxygen absorption in the earth’s atmosphere,” Aerospace Corp., Los Angeles, CA, USA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.
2. J. H. Davis and J. R. Cogdell, “Calibration program for the 16-foot antenna,” Elect. Eng. Res. Lab., Univ. Texas, Austin, TX, USA, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

*Basic format for handbooks:*

*Name of Manual/Handbook, x* ed., Abbrev. Name of Co., City of Co., Abbrev. State, Country, year, pp. *xxx-xxx.*

*Examples:*

1. *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, USA, 1985, pp. 44–60.
2. *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, USA, 1989.

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J. K. Author, “Title of chapter in the book,” in *Title of Published Book*, *x*th ed. City of Publisher, State, Country: Abbrev. of Publisher, year, ch. *x*, sec. *x*, pp. *xxx–xxx*. [Online]. Available: http://www.web.com

*Examples:*

1. G. O. Young, “Synthetic structure of industrial plastics,” in Plastics, vol. 3, Polymers of Hexadromicon, J. Peters, Ed., 2nd ed. New York, NY, USA: McGraw-Hill, 1964, pp. 15-64. [Online]. Available: http://www.bookref.com.
2. *The Founders’ Constitution*, Philip B. Kurland and Ralph Lerner, eds., Chicago, IL, USA: Univ. Chicago Press, 1987. [Online]. Available: http://press-pubs.uchicago.edu/founders/
3. The Terahertz Wave eBook. ZOmega Terahertz Corp., 2014. [Online]. Available: http://dl.z-thz.com/eBook/zomega\_ebook\_pdf\_1206\_sr.pdf. Accessed on: May 19, 2014.
4. Philip B. Kurland and Ralph Lerner, eds., *The Founders’ Constitution.* Chicago, IL, USA: Univ. of Chicago Press, 1987, Accessed on: Feb. 28, 2010, [Online] Available: http://press-pubs.uchicago.edu/founders/

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*Examples:*

1. J. S. Turner, “New directions in communications,” *IEEE J. Sel. Areas Commun*., vol. 13, no. 1, pp. 11-23, Jan. 1995.
2. W. P. Risk, G. S. Kino, and H. J. Shaw, “Fiber-optic frequency shifter using a surface acoustic wave incident at an oblique angle,” *Opt. Lett.*, vol. 11, no. 2, pp. 115–117, Feb. 1986.
3. P. Kopyt *et al., “*Electric properties of graphene-based conductive layers from DC up to terahertz range,” *IEEE THz Sci. Technol.,* to be published. DOI: 10.1109/TTHZ.2016.2544142.

*Basic format for papers presented at conferences (when available online):*

J.K. Author. (year, month). Title. presented at abbrev. conference title. [Type of Medium]. Available: site/path/file

*Example:*

1. PROCESS Corporation, Boston, MA, USA. Intranets: Internet technologies deployed behind the firewall for corporate productivity. Presented at INET96 Annual Meeting. [Online]. Available: http://home.process.com/Intranets/wp2.htp

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1. R. J. Hijmans and J. van Etten, “Raster: Geographic analysis and modeling with raster data,” R Package Version 2.0-12, Jan. 12, 2012. [Online]. Available: http://CRAN.R-project.org/package=raster
2. Teralyzer. Lytera UG, Kirchhain, Germany [Online]. Available: http://www.lytera.de/Terahertz\_THz\_Spectroscopy.php?id=home, Accessed on: Jun. 5, 2014

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*Example:*

1. U.S. House. 102nd Congress, 1st Session. (1991, Jan. 11). *H. Con. Res. 1, Sense of the Congress on Approval of Military Action*. [Online]. Available: LEXIS Library: GENFED File: BILLS

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Name of the invention, by inventor’s name. (year, month day). Patent Number[Type of medium]. Available: site/path/file

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[Online]. Available: NEXIS Library: LEXPAT File: DES

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J. K. Author, “Title of paper,” in *Abbreviated Name of Conf.*, City of Conf., Abbrev. State (if given), Country, year, pp. *xxxxxx.*

*Example:*

1. D. B. Payne and J. R. Stern, “Wavelength-switched pas- sively coupled single-mode optical network,” in *Proc. IOOC-ECOC,* Boston, MA, USA,1985,   
   pp. 585–590.

*Example for papers presented at conferences (unpublished):*

1. D. Ebehard and E. Voges, “Digital single sideband detection for interferometric sensors,” presented at the *2nd Int. Conf. Optical Fiber Sensors,* Stuttgart, Germany, Jan. 2-5, 1984.

*Basic format for patents:*

J. K. Author, “Title of patent,” U.S. Patent *x xxx xxx*, Abbrev. Month, day, year.

*Example:*

1. G. Brandli and M. Dick, “Alternating current fed power supply,” U.S. Patent 4 084 217, Nov. 4, 1978.

*Basic format**for theses (M.S.) and dissertations (Ph.D.):*

a) J. K. Author, “Title of thesis,” M.S. thesis, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

b) J. K. Author, “Title of dissertation,” Ph.D. dissertation, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

*Examples:*

1. J. O. Williams, “Narrow-band analyzer,” Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, USA, 1993.
2. N. Kawasaki, “Parametric study of thermal and chemical nonequilibrium nozzle flow,” M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

*Basic format for the most common types of unpublished references:*

a) J. K. Author, private communication, Abbrev. Month, year.

b) J. K. Author, “Title of paper,” unpublished.

c) J. K. Author, “Title of paper,” to be published.

*Examples:*

1. A. Harrison, private communication, May 1995.
2. B. Smith, “An approach to graphs of linear forms,” unpublished.
3. A. Brahms, “Representation error for real numbers in binary computer arithmetic,” IEEE Computer Group Repository, Paper R-67-85.

*Basic formats for standards:*

a) *Title of Standard*, Standard number, date.

b) *Title of Standard*, Standard number, Corporate author, location, date.

*Examples:*

1. IEEE Criteria for Class IE Electric Systems, IEEE Standard 308, 1969.
2. Letter Symbols for Quantities, ANSI Standard Y10.5-1968.

*Article number in reference examples:*

1. R. Fardel, M. Nagel, F. Nuesch, T. Lippert, and A. Wokaun, “Fabrication of organic light emitting diode pixels by laser-assisted forward transfer,” *Appl. Phys. Lett.*, vol. 91, no. 6, Aug. 2007, Art. no. 061103.
2. J. Zhang and N. Tansu, “Optical gain and laser characteristics of InGaN quantum wells on ternary InGaN substrates,” *IEEE Photon. J.*, vol. 5, no. 2, Apr. 2013, Art. no. 2600111

*Example when using et al.:*

1. S. Azodolmolky *et al.*, Experimental demonstration of an impairment aware network planning and operation tool for transparent/translucent optical networks,” *J. Lightw. Technol.*, vol. 29, no. 4, pp. 439–448, Sep. 2011.

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