



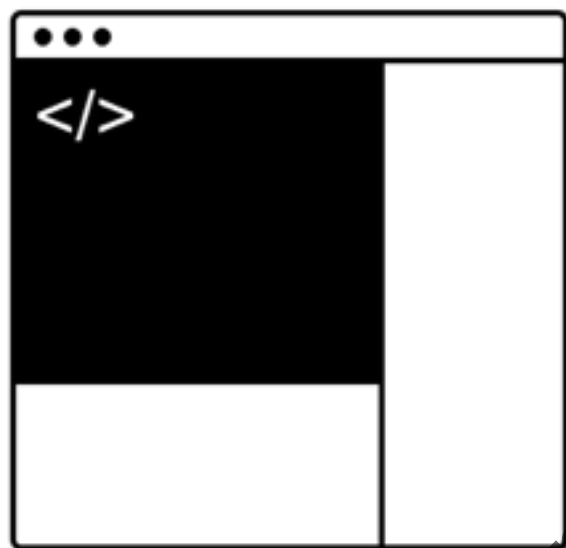
Advances in Cartography

“Explanatory Semantic Relatedness and Explicit Spatialization for Exploratory Search”

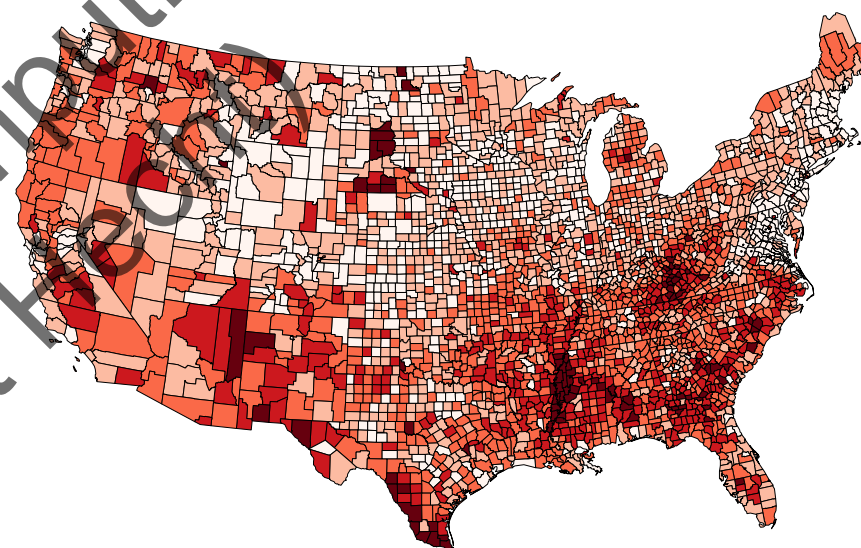
Brent Hecht, Samuel Carton, Mahmood Quaderi, Johannes Schöning,
Martin Raubal, Darren Gergle, Doug Downey

Proceedings of ACM SIGIR 2012

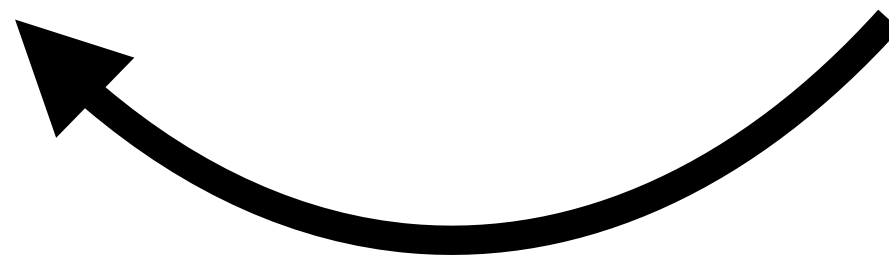
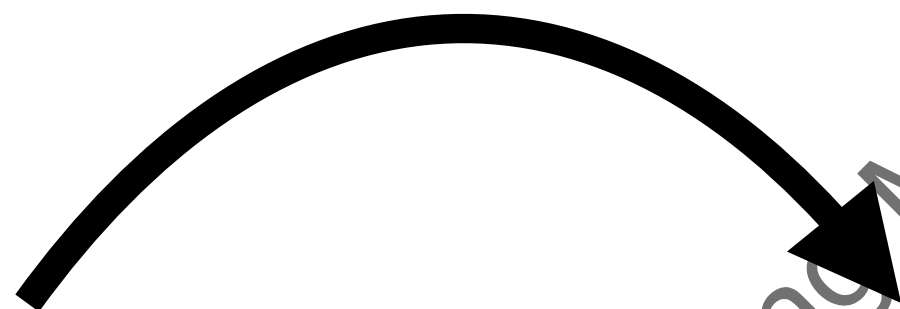
Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium



Computing



Spatial





Douglas Downey



Samuel Carton



Mahmood Quaderi



Darren Gergle



Johannes Schöning



Martin Raubal



Brent Hecht

Computer Science

**Geographic Information
Science**

Google™

bing™

Slides for Spatial Computing MOOC
(by Brent Hecht)

mayor of minneapolis, mn - ...

www.bing.com/search?q=mayor+of+minneapolis%2C+mn&go=Submit+Query&qs=ds&form=

Google

bing

mayor of minneapolis, mn

Web Images Videos Maps News More

Also try: Mayor RT Rybak · Minnesota Mayors · Mayor of Minneapolis Salary

7,610,000 RESULTS Any time

Minneapolis mayor
Betsy Hodges
Data from Wikipedia

Minneapolis Mayor's Office
www.minneapolismn.gov/mayor
We would like to show you a description here but the site won't allow us.

Minneapolis mayoral candidate bio: Betsy Hodges | The ...
blogs.mprnews.org/.../minneapolis-mayoral-candidate-bio-betsy-hodges
Betsy Hodges enjoys balancing the billion-dollar **Minneapolis** city budget. And as chair of the City Council's Ways and Means/Budget Committee for the past four years ...

Editorial endorsement: Betsy Hodges for Minneapolis mayor ...
www.startribune.com · Opinion > Editorials
Oct 26, 2013 · **Minneapolis mayoral** hopeful **Betsy Hodges**. Jeff Wheeler, **Star Tribune** EDITOR'S NOTE. Over the past several weeks, members of the **Star Tribune** ...

Betsy Hodges - Wikipedia, the free encyclopedia
en.wikipedia.org/wiki/Betsy_Hodges
Elizabeth "Betsy" A. **Hodges** (born September 7, 1969) is the **Mayor of Minneapolis, Minnesota**. A member of the **Minnesota Democratic-Farmer-Labor Party**, she ...

Betsy Hodges

Elizabeth "Betsy" A. Hodges is the Mayor of Minneapolis, Minnesota. A member of the Minnesota ... +
en.wikipedia.org

en.wikipedia.org

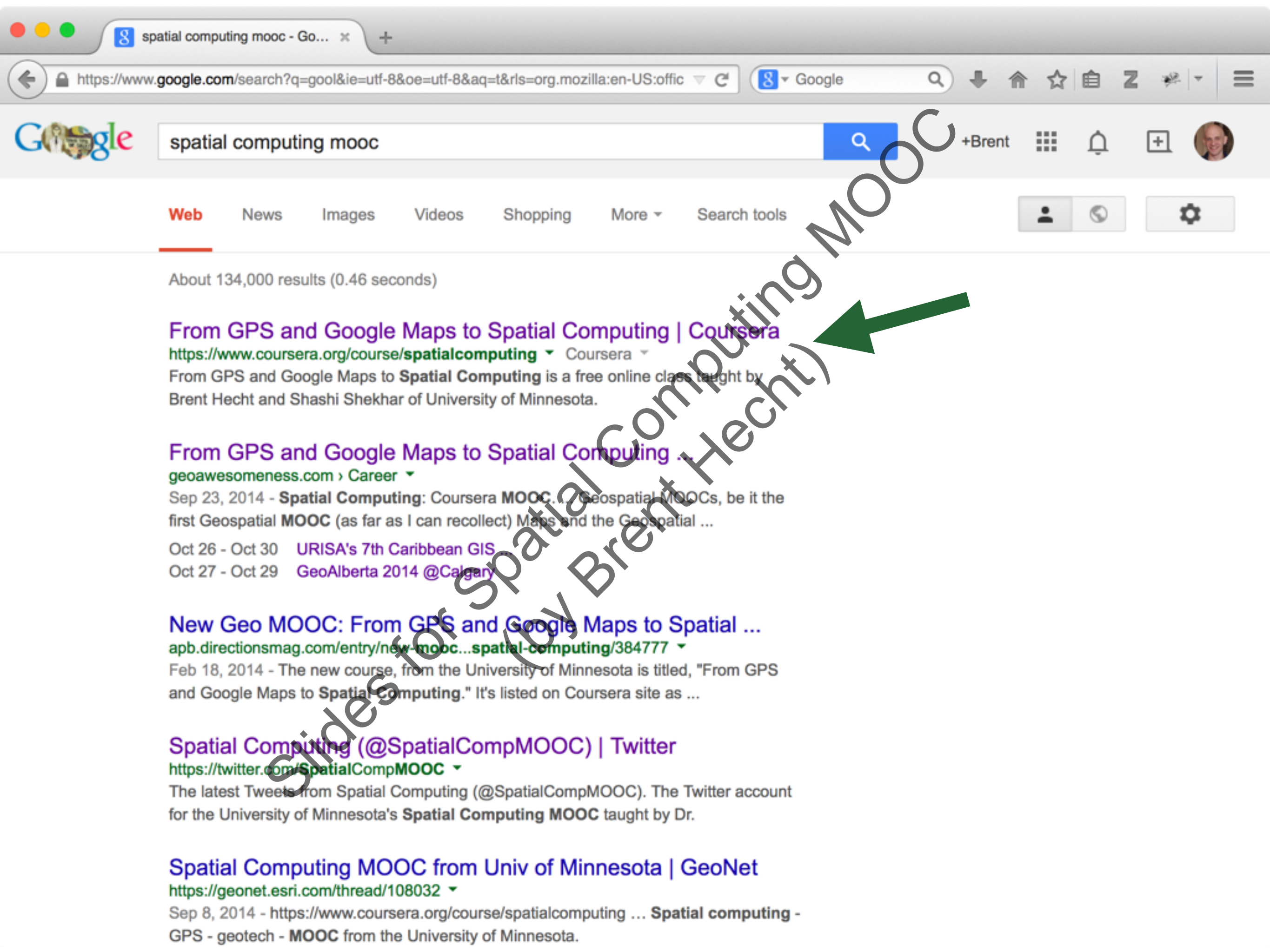
[in](#) LinkedIn

Born: Sep 07, 1969 (age 45) · **Minnesota, United States**

Spouse: [Gary Cunningham](#) (Since 2011)

Office: Mayor of Minneapolis (2014 - present)

Party: [Minnesota Democratic-Farmer-Labor Party](#)



spatial computing mooc



+Brent



Web

News

Images

Videos

Shopping

More ▾

Search tools



About 134,000 results (0.46 seconds)

From GPS and Google Maps to Spatial Computing | Coursera

<https://www.coursera.org/course/spatialcomputing> ▾ Coursera ▾

From GPS and Google Maps to **Spatial Computing** is a free online class taught by Brent Hecht and Shashi Shekhar of University of Minnesota.

From GPS and Google Maps to Spatial Computing ...

geoawesomeness.com ▾ Career ▾

Sep 23, 2014 - **Spatial Computing**: Coursera **MOOC**... Geospatial MOOCs, be it the first Geospatial **MOOC** (as far as I can recollect) Maps and the Geospatial ...

Oct 26 - Oct 30 [URISA's 7th Caribbean GIS](#) ...

Oct 27 - Oct 29 [GeoAlberta 2014 @Calgary](#)

New Geo MOOC: From GPS and Google Maps to Spatial ...

apb.directionsmag.com/entry/new-mooc...spatial-computing/384777 ▾

Feb 18, 2014 - The new course, from the University of Minnesota is titled, "From GPS and Google Maps to **Spatial Computing**." It's listed on Coursera site as ...

Spatial Computing (@SpatialCompMOOC) | Twitter

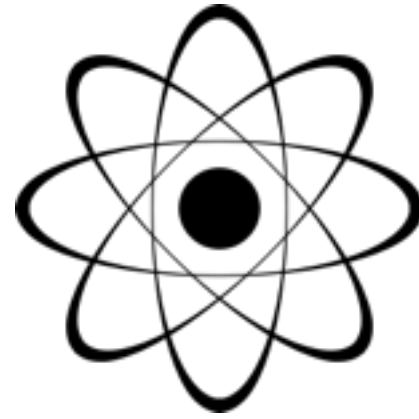
<https://twitter.com/SpatialCompMOOC> ▾

The latest Tweets from Spatial Computing (@SpatialCompMOOC). The Twitter account for the University of Minnesota's **Spatial Computing MOOC** taught by Dr.

Spatial Computing MOOC from Univ of Minnesota | GeoNet

<https://geonet.esri.com/thread/108032> ▾

Sep 8, 2014 - <https://www.coursera.org/course/spatialcomputing> ... **Spatial computing** - GPS - geotech - **MOOC** from the University of Minnesota.



Nuclear Weapons



Student



Consultant



Intelligence
Analyst

Slides for Spatial Computing MOOC
(by Brent Hecht)



nuclear weapon



+Brent



Share



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Search tools



About 47,900,000 results (0.38 seconds)

[Nuclear weapon - Wikipedia, the free encyclopedia](#)

[en.wikipedia.org/wiki/Nuclear_weapon](#) ▾

A **nuclear weapon** is an explosive device that derives its destructive force from nuclear reactions, either fission or a combination of fission and fusion.

[Thermonuclear weapon](#) - [List of states with nuclear ...](#) - [History of nuclear weapons](#)

[List of states with nuclear weapons - Wikipedia, the free encyclopedia](#)

[en.wikipedia.org/wiki/List_of_states_with_nuclear_weapons](#) ▾

Other states with nuclear weapons (India, Pakistan, North Korea). Other states ...

[News for nuclear weapon](#)



[Eric Schlosser on US nuclear weapons: 'People are getting sloppy'](#)

The Guardian - 2 days ago

Q&A: Author of Command and Control discusses recent incidents involving those responsible for the US nuclear arsenal.

[Nuclear group: Time Iran would need to make uranium for a bomb 'too short'](#)

CNN - 3 days ago

[The rise of nuclear bombs: Amazing time-lapse map reveals 2056 WMDs that ...](#)

Daily Mail - 3 days ago

[UNODA - Nuclear Weapons Home](#)

[www.un.org/disarmament/WMD/Nuclear/](#) ▾

Nuclear weapons are the most dangerous weapons on earth. One can destroy a whole city, potentially killing millions, and jeopardizing the natural environment ...

[The Nuclear Weapon Archive - A Guide to Nuclear Weapons](#)

[nuclearweaponarchive.org/](#) ▾

The most comprehensive guide to **nuclear weapons** on the Internet.

[Nuclear Bombs - How Stuff Works](#)

[www.howstuffworks.com/nuclear-bomb.htm](#) ▾

Nuclear bombs are the most serious looming threat in just about any major conflict.

Closed Information Requests

e.g. “Mayor of
Minneapolis, MN”



Google bing™

Navigational Queries

e.g. “spatial computing
mooc”



Google™ bing™

Exploratory Search

e.g. “Nuclear weapons”



???

[White and Roth 2009]

“...an information-seeking problem context that is open-ended, persistent, and multifaceted... Exploratory search systems support this through symbiotic human-machine relationships that provide guidance in **exploring unfamiliar information landscapes.**”

[White and Roth 2009]



Douglas Downey



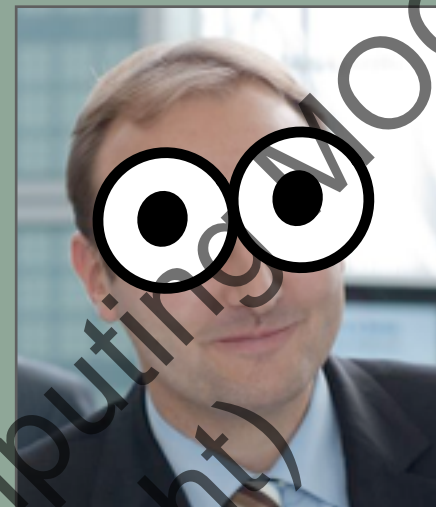
Samuel Carton



Mahmood Quaderi



Darren Gergle



Johannes Schöning



Martin Raubal



Brent Hecht

Computer Science

**Geographic Information
Science**

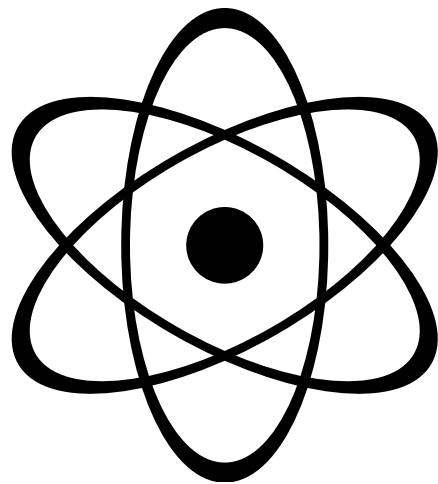
Thematic Cartography to the Rescue?

Slides for Spatial Computing MOOC
(by Brent Hecht)

The **BIG** question is then...

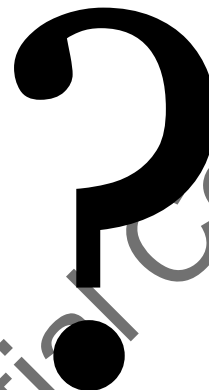
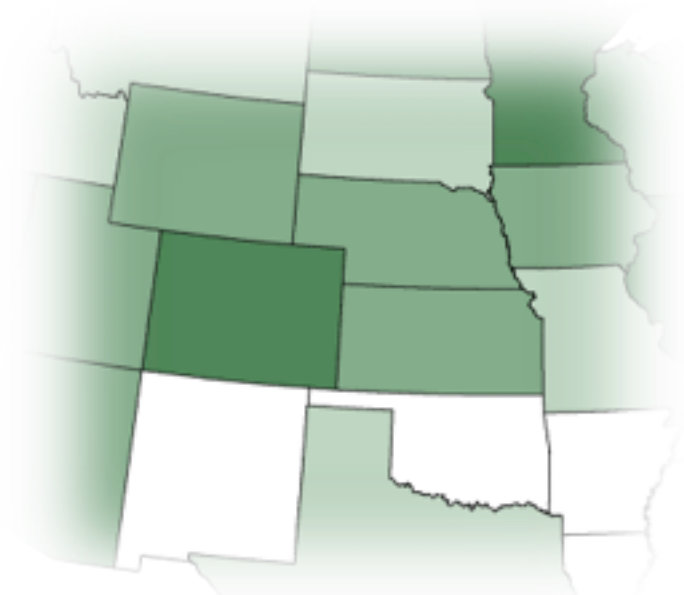
Query Concept

(e.g. “Nuclear weapon”)

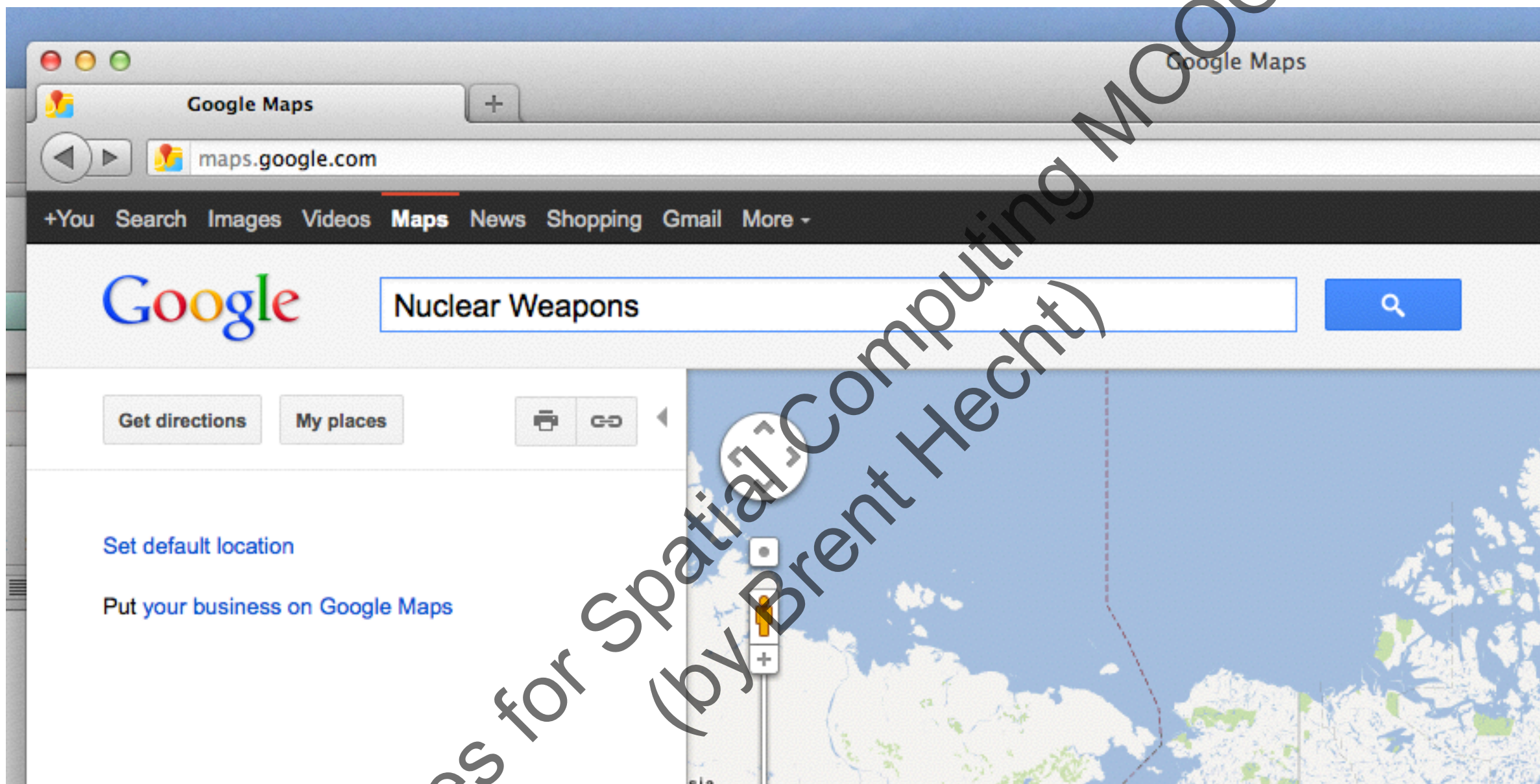


Thematic Cartography

(e.g. choropleth maps)



Slides for Spatial Computing MOOC
(by Brent Hecht)



nuclear weapon

Search the web for **nuclear weapon** Top
web result shown

Nuclear weapon - Wikipedia, the free encyclopedia

A **nuclear weapon** is an explosive device that derives its destructive force from nuclear reactions, either fission or a combination of fission and fusion.
en.wikipedia.org

- A National Museum of Nuclear Science & History**
601 Eubank Boulevard Southeast,
Albuquerque, NM
(505) 245-2137 · nuclearmuseum.org
★★★★☆ 19 reviews
manhattan project · smithsonian affiliate · atomic
cannon · weapons · atomic age
"In many ways, it does an admirable job of
introducing young people to the development of
nuclear power, its devastating effects as a **weapon**
and a threat, ..." - virtualtourist.com
- B Hiroshima Peace Memorial Museum**
Japan, Hiroshima Prefecture, Hiroshima,
Naka Ward, Nakajimacho, 1 - 2
+81 82-241-5246 · hiroshima-spirit.jp
★★★★★ 17 reviews
"Whoever won the race and produced the first
nuclear bomb felt they had to drop it before the
others could. The narration carefully deflected blame
from ..." - cemeterytravel.com
- C Campaign For Nuclear Disarmament**
22A Beswick Street, Manchester,
Lancashire M4 7HR, United Kingdom
+44 161 273 8283 · cnduk.org
"rudenski, Depleted" Uranium Munitions:
Nuclear Waste as a **Weapon** rudenski contact
rudenski email rudenski 2/21/2006 6:47:53 PM
- curezone.com
- D Exeter Campaign for Nuclear
Disarmament**
24 New Bridge Street, Exeter, EX4 3AU

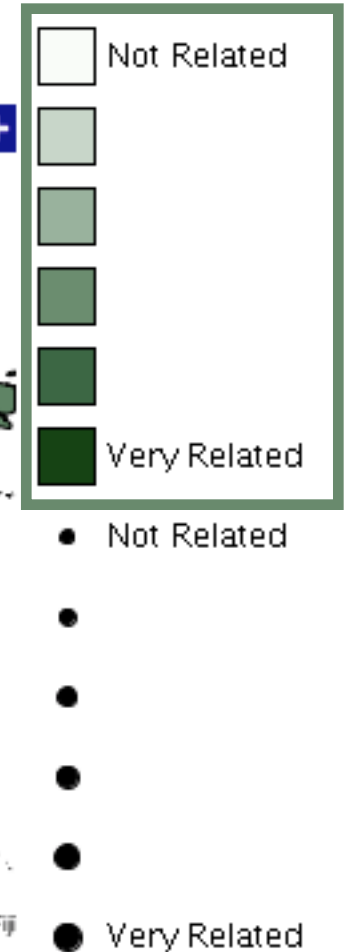


ATLASIFY

Slides for Spatial Computing MOOC
(by Brent Hecht)

Make Reference System

Options



Thematic Maps

Make Reference System

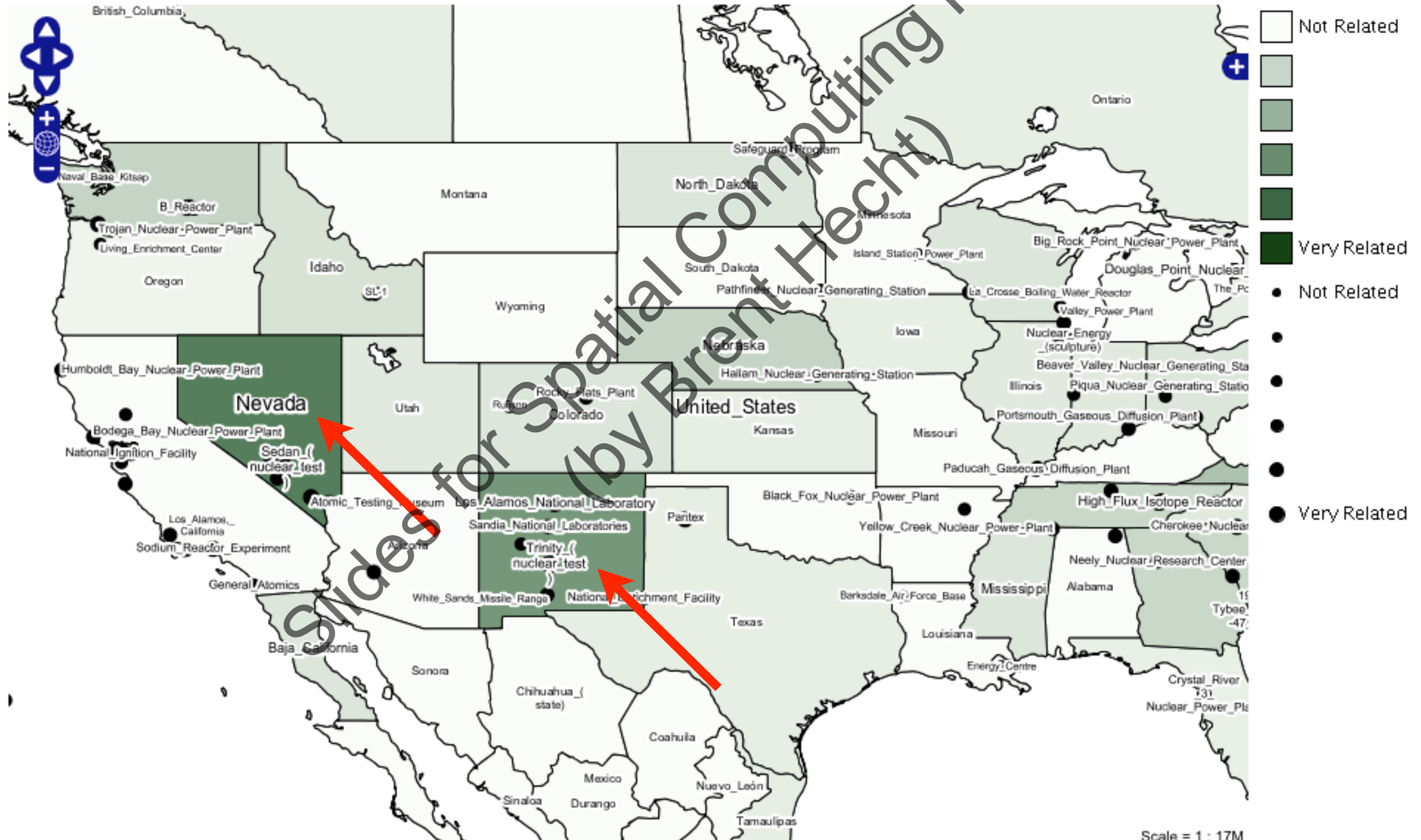
Concept: Nuclear_weapon

Language: English

Atlas of: The Earth

Execute!

Options



Thematic Maps

Make Reference System

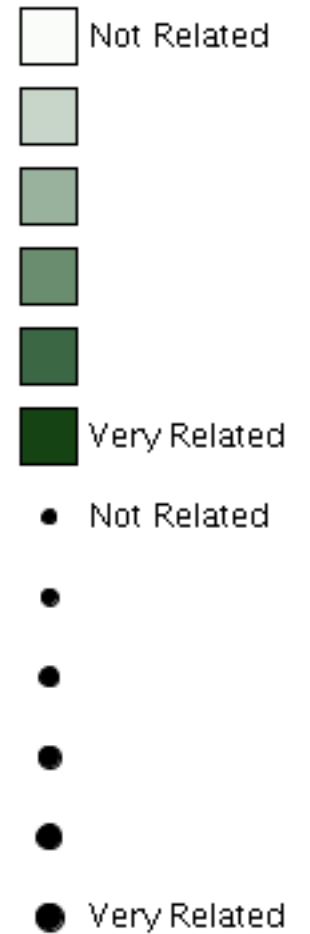
Concept: Nuclear_weapon

Language: English

Atlas of: The Earth

Execute!

Options



Thematic Maps

Make Reference System

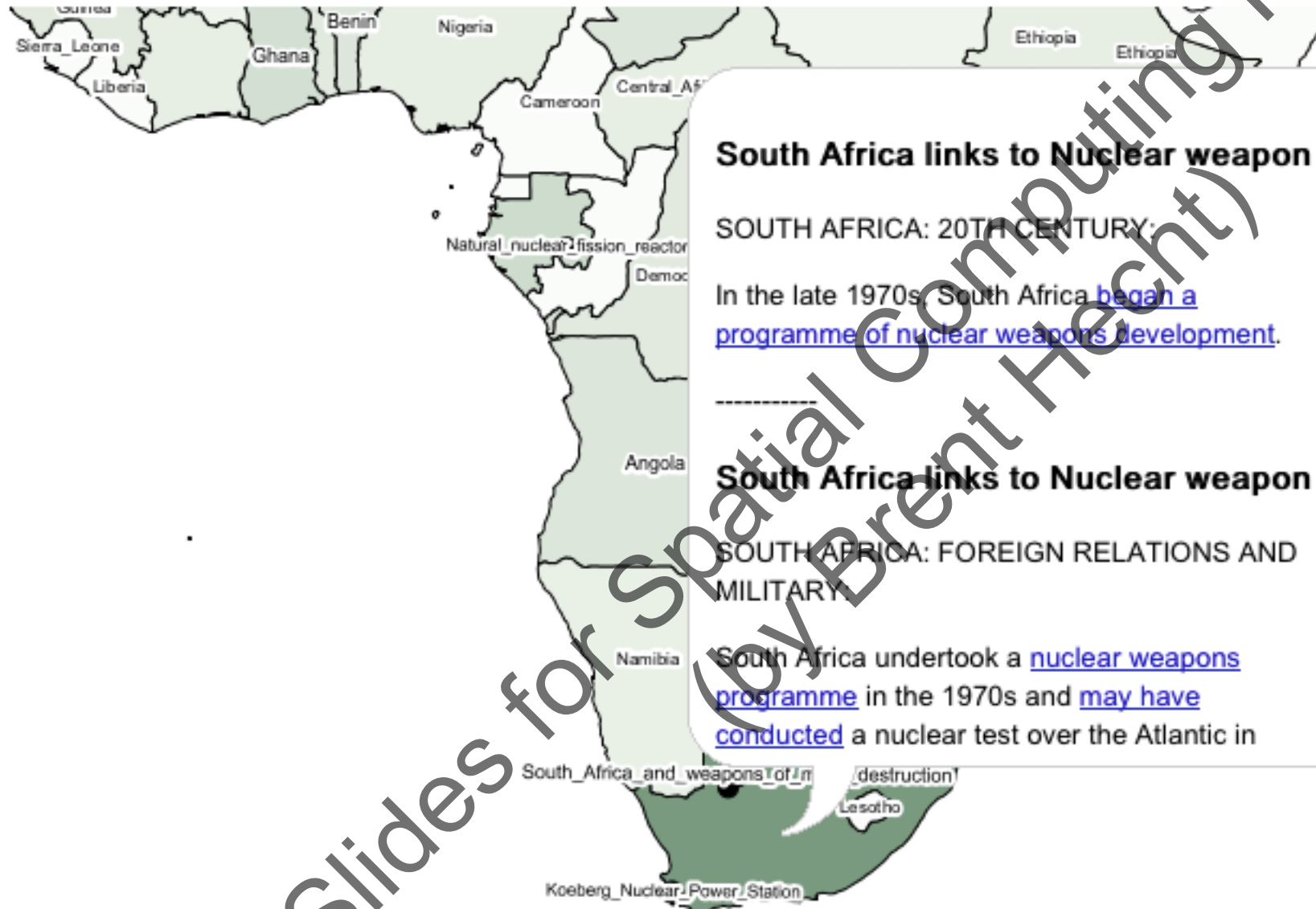
Concept: Nuclear_weapon

Language: English

Atlas of: The Earth

Execute!

Options



Not Related



Very Related

• Not Related



• Very Related

Thematic Maps

Make Reference System

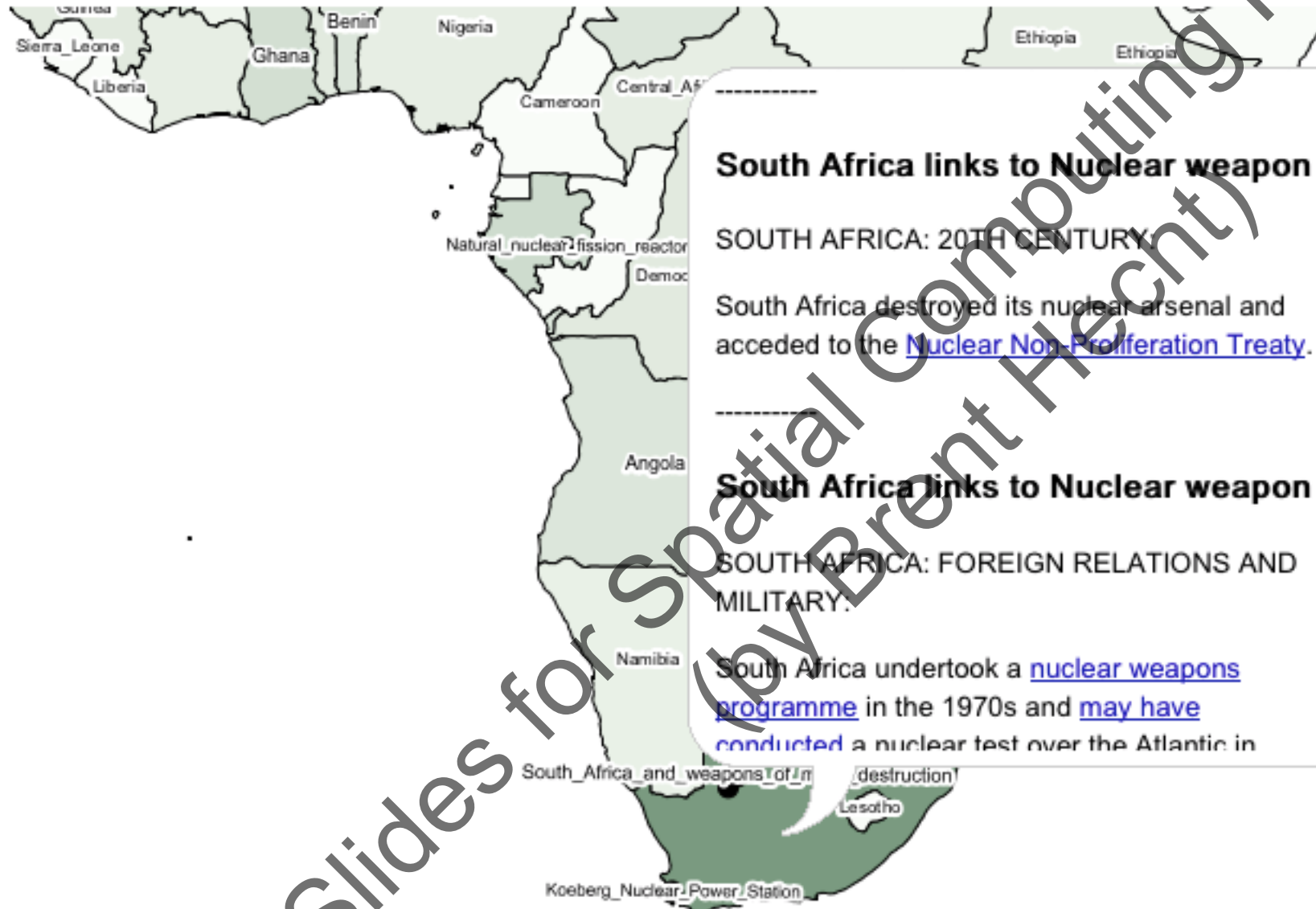
Concept: Nuclear_weapon

Language: English

Atlas of: The Earth

Execute!

Options



Not Related



Very Related

• Not Related



• Very Related



limited in one
very important
way....

Slides for Spatial Computing MOOC
(by Brett Hecht)

Thematic Maps

Make Reference System

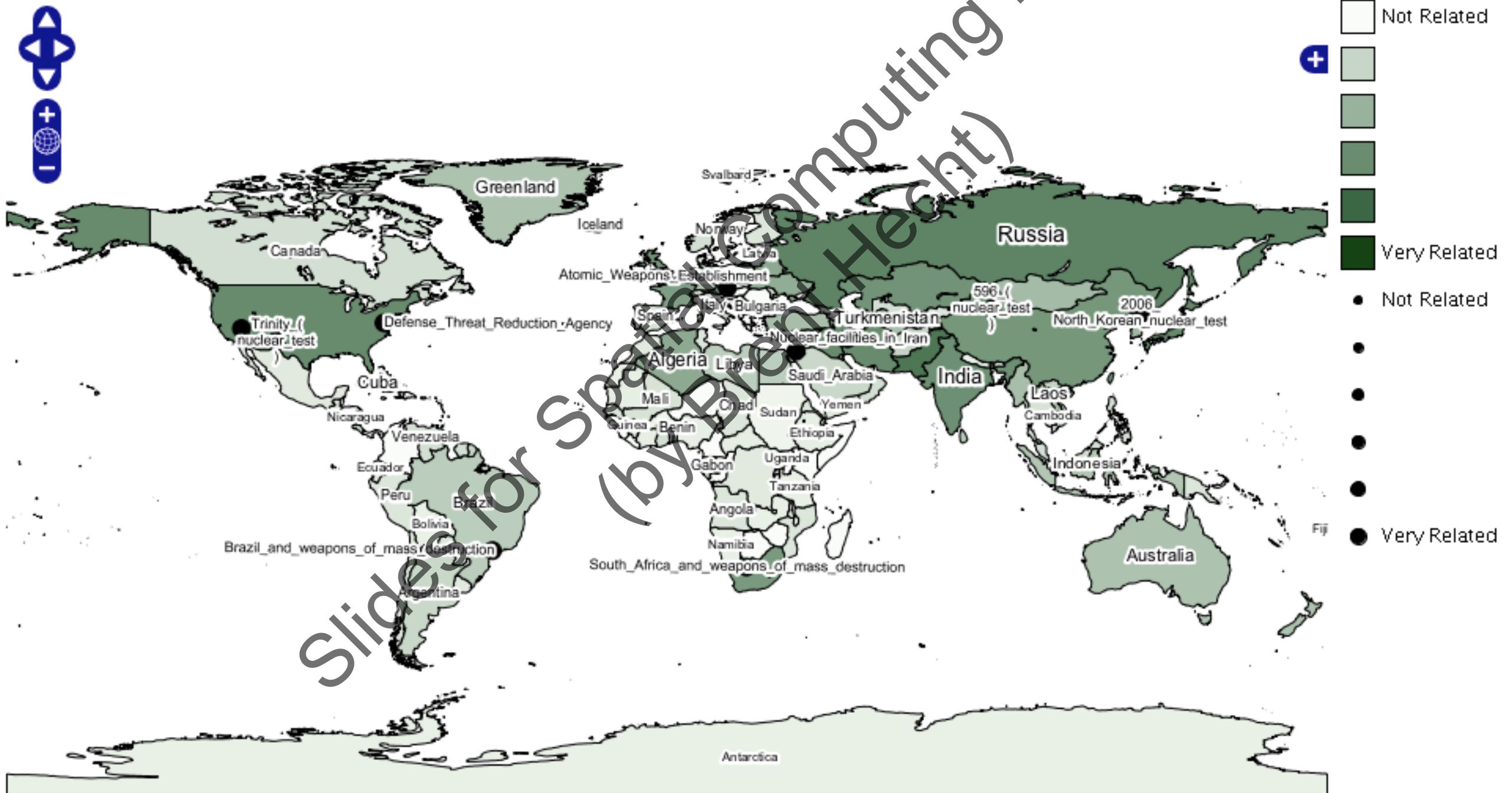
Concept: Nuclear_weapon

Language: English

Atlas of: The Earth

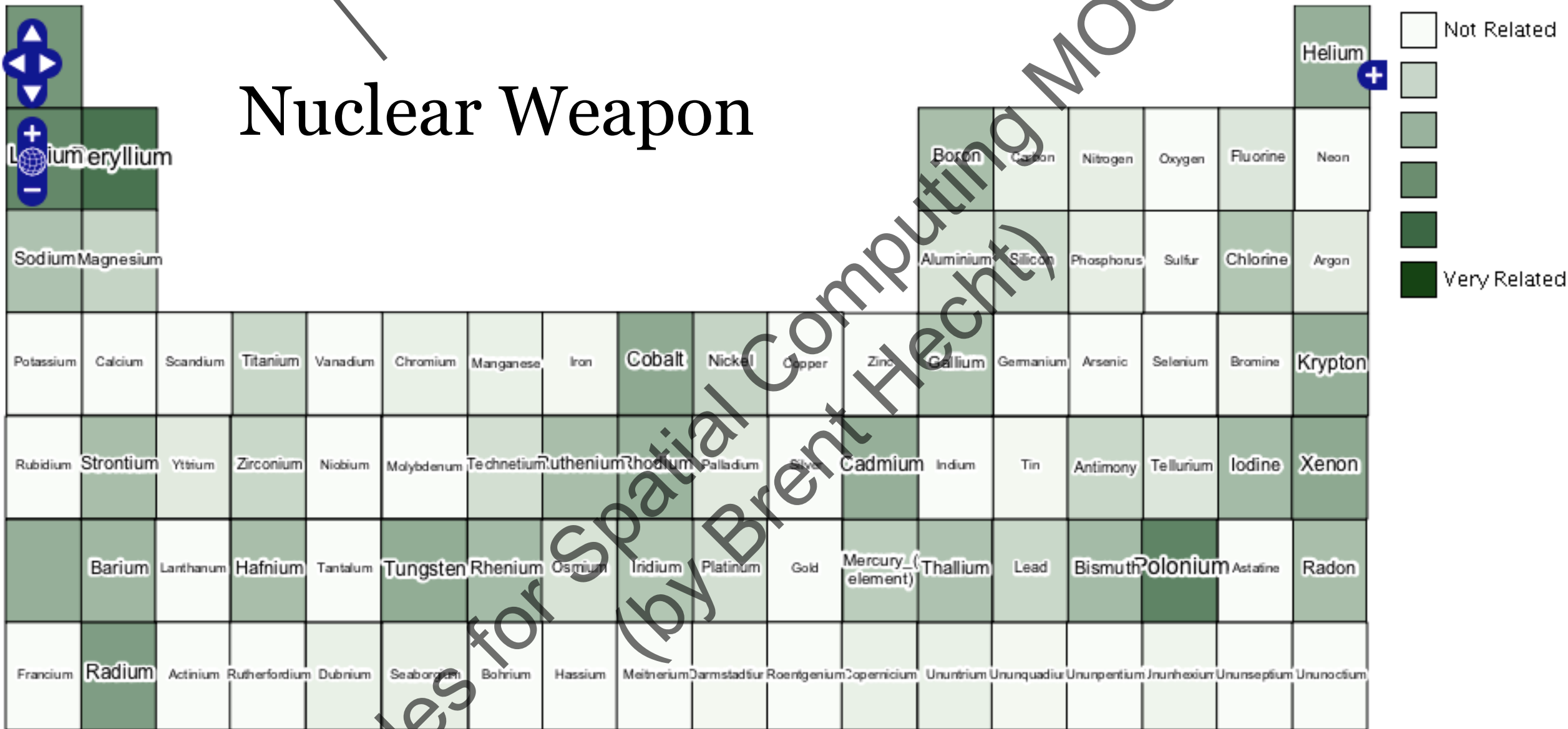
Execute!

Options

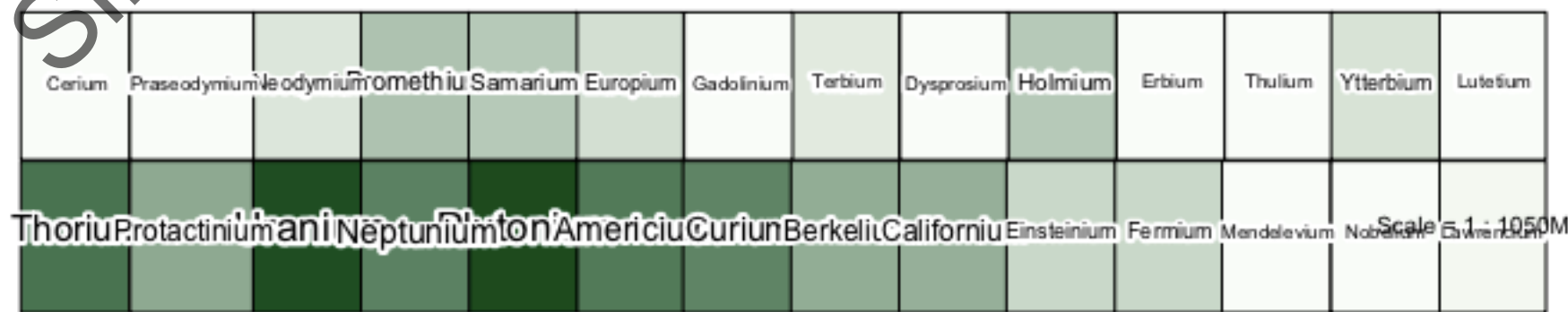


Thematic Maps Make Reference System

Concept: Language: Atlas of:



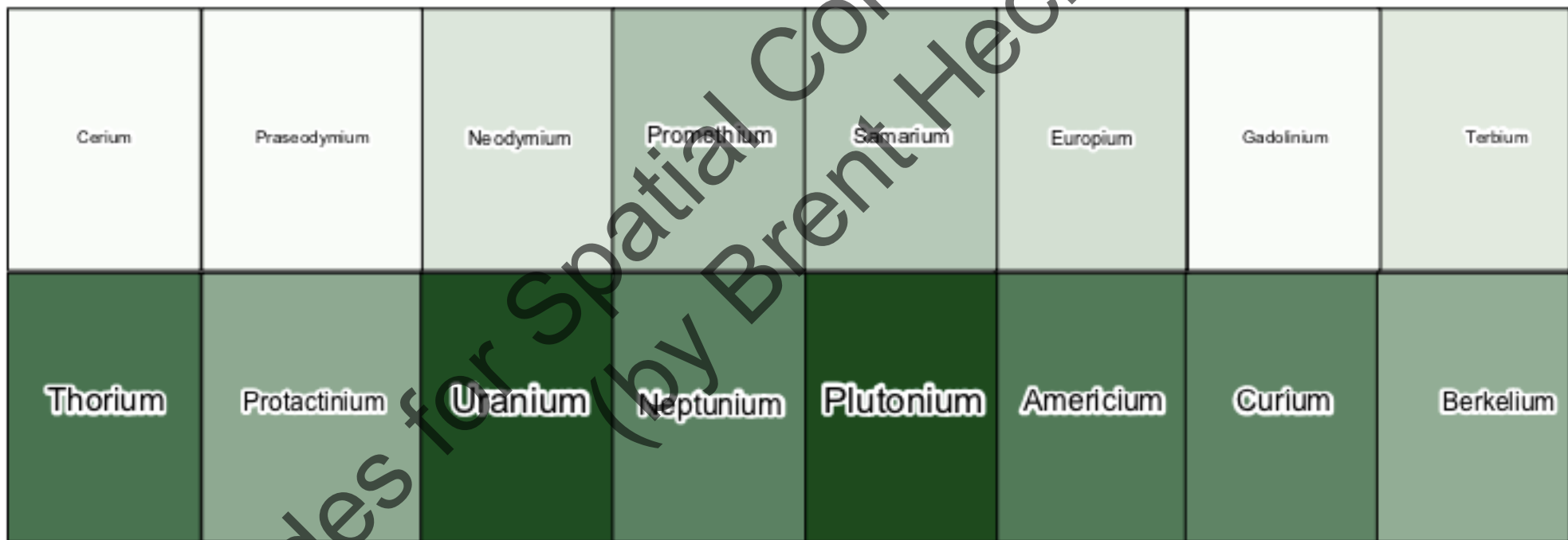
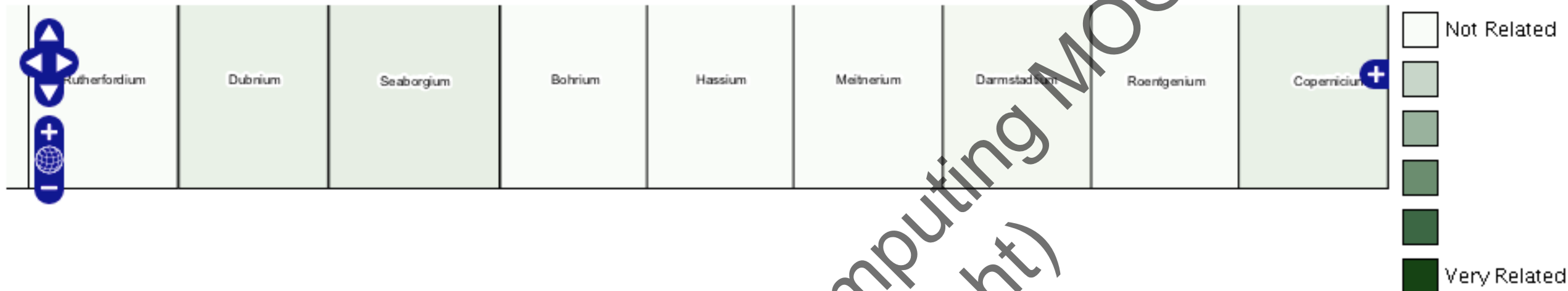
Nuclear Weapon



Scale 1:1050M

Thematic Maps Make Reference System

Concept: Language: Atlas of:



Thematic Maps Make Reference System

Concept: Language: Atlas of:



Thematic Maps

Make Reference System

Concept:

Nuclear_weapon

Language:

English

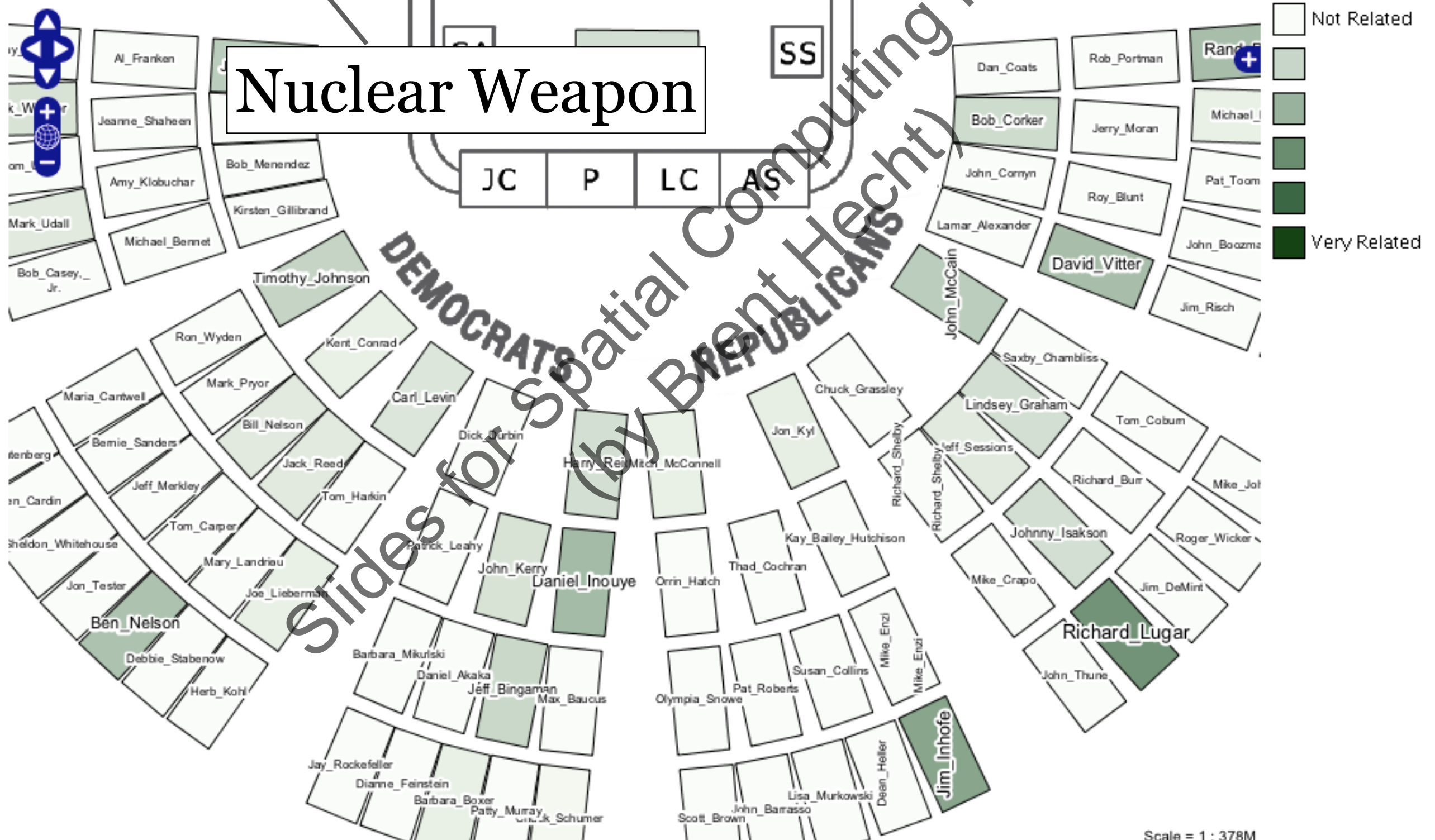
Atlas of:

The U.S. Senate Chamber (Senators)

Execute!

Options

Nuclear Weapon





Thematic Maps

Make Reference System

Concept:

Nuclear_weapon

Language:

English

SR Measure:

Atlasify353

Atlas of:

History



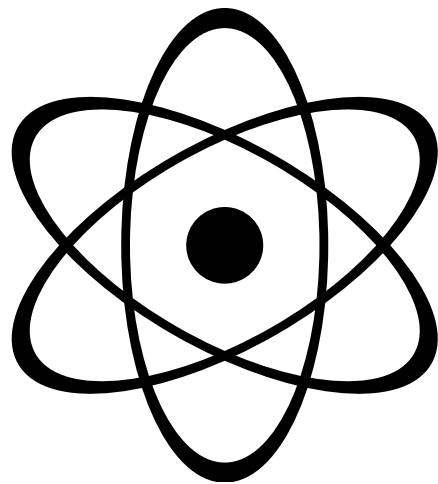
Nuclear Weapon



The **BIG** question is then...

Query Concept

(e.g. “Nuclear weapon”)



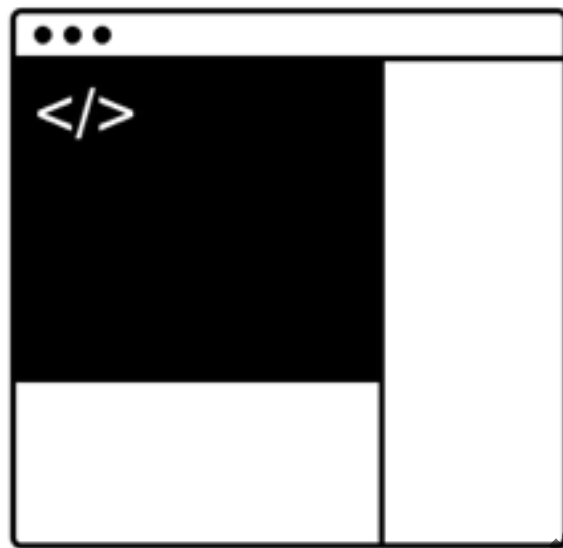
Thematic Cartography

(e.g. choropleth maps)

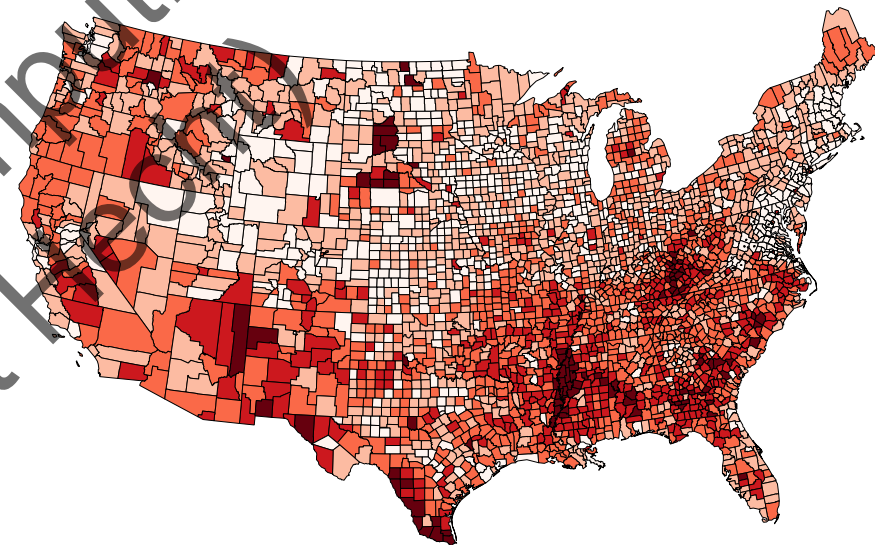


	Aluminum	Silicon	Phosphorus	Sulfur	Chromium	Argon
Zinc	Gallium	Germanium	Arsenic	Selenium	Bromine	Krypton
Strontium	Indium	Tin	Antimony	Tellurium	Iodine	Xenon
Barium	Thallium	Lead	Bismuth	Polonium	Astatine	Radon
Francium	Ununbium	Ununquadium	Ununseptium	Ununhexium	Ununpentium	Ununquadium

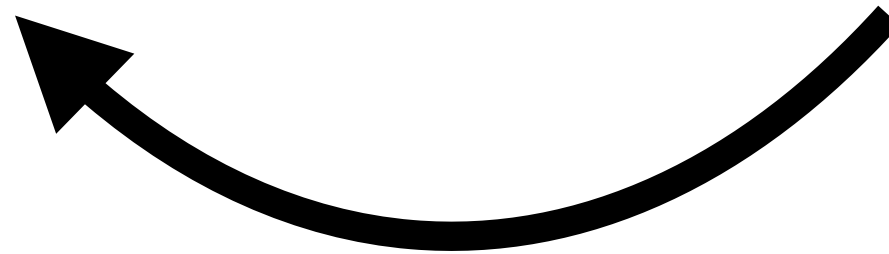
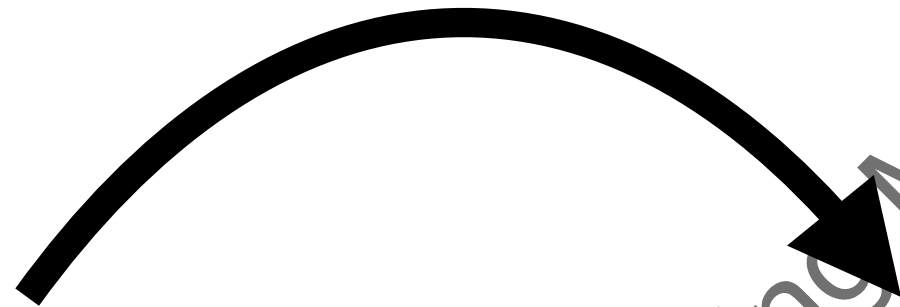
Slides for Spatial Computing MOOC
(by Brent Hecht)



Computing



Spatial



Advances in Cartography

“Explanatory Semantic Relatedness and Explicit Spatialization for Exploratory Search”

Attributions

By Base map: BART Bart-logo.svg:ChrisRuvolo at en.wikipedia 20_airtransportation.svg: AIGA symbol sign collection derivative work: Train2104 [CC-BY-SA-3.0 (<http://creativecommons.org/licenses/by-sa/3.0>)], from Wikimedia Commons

"Cell tower in jovel chiapas" by Leogeograph - Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Cell_tower_in_jovel_chiapas.JPG#mediaviewer/File:Cell_tower_in_jovel_chiapas.JPG

“new holland tractor” by Dan Davison / CC BY 2.0 (<https://flic.kr/p/8qXrXN>)

[“Wifi”] By RRZEicons (Own work) [CC-BY-SA-3.0 (<http://creativecommons.org/licenses/by-sa/3.0>)], via Wikimedia Commons

“Smartphone” by Samuel Q. Green from The Noun Project

“Globe” by Samuel Q. Green from The Noun Project

Slides for Spatial Computing MOOC

(by Brent Hecht)



Advances in Positioning

“SubwayPS: Towards Enabling Smartphone Positioning in Underground Public Transportation Systems”

Thomas Stockx, Brent Hecht, Johannes Schöning
Proceedings of ACM SIGSPATIAL 2014

Note:

Richmond-Millbrae trains
terminate at Daly City in
the evening and on week-
ends, and Pittsburg/Bay
Point-SFO trains continue
to Millbrae in this event.

Millbrae

South Ha

SubwayPS: Towards Smartphone Positioning in Underground Public Transportation Systems

Thomas Stockx

Expertise Ctr. For Digital Media
Hasselt University - tUL - iMinds
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Brent Hecht

GroupLens Research
University of Minnesota
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Johannes Schöning

Expertise Ctr. For Digital Media
Hasselt University - tUL - iMinds
johannes.schoening@uhasselt.be

ABSTRACT

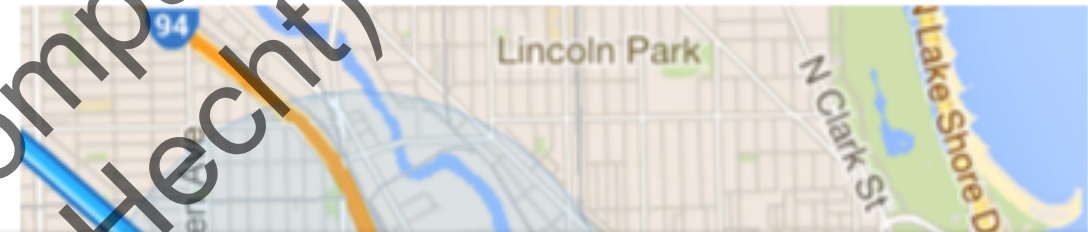
Thanks to rapid advances in technologies like GPS and Wi-Fi positioning, smartphone users are able to determine their location almost everywhere they go. This is not true, however, of people who are traveling in underground public transportation networks, one of the few types of high-traffic areas where smartphones do not have access to accurate position information. In this paper, we introduce the problem of underground transport positioning on smartphones and present *SubwayPS*, an accelerometer-based positioning technique that allows smartphones to determine their location substantially better than baseline approaches, even deep beneath city streets. We highlight several immediate applications of positioning in subway networks in domains ranging from mobile advertising to mobile maps and present *MetroNavigator*, a proof-of-concept smartphone and smartwatch app that notifies users of upcoming points-of-interest and alerts them when it is time to get ready to exit the train.

Categories and Subject Descriptors

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Keywords

mobile navigation, positioning, mobile devices,



Red dots are underground stations. One could easily miss their stop if they relied solely on current positioning

Key Types of Signal-based Positioning

in your smartphone and in general



1. Satellite-based Positioning
2. Wifi Positioning
3. Cellular Positioning

Signal-based
Positioning



GNSS



Wifi



Cell



Urban Canyon



GNSS



Wifi



Cell



Rural areas



GNSS



Wifi



Cell



Subways



GNSS

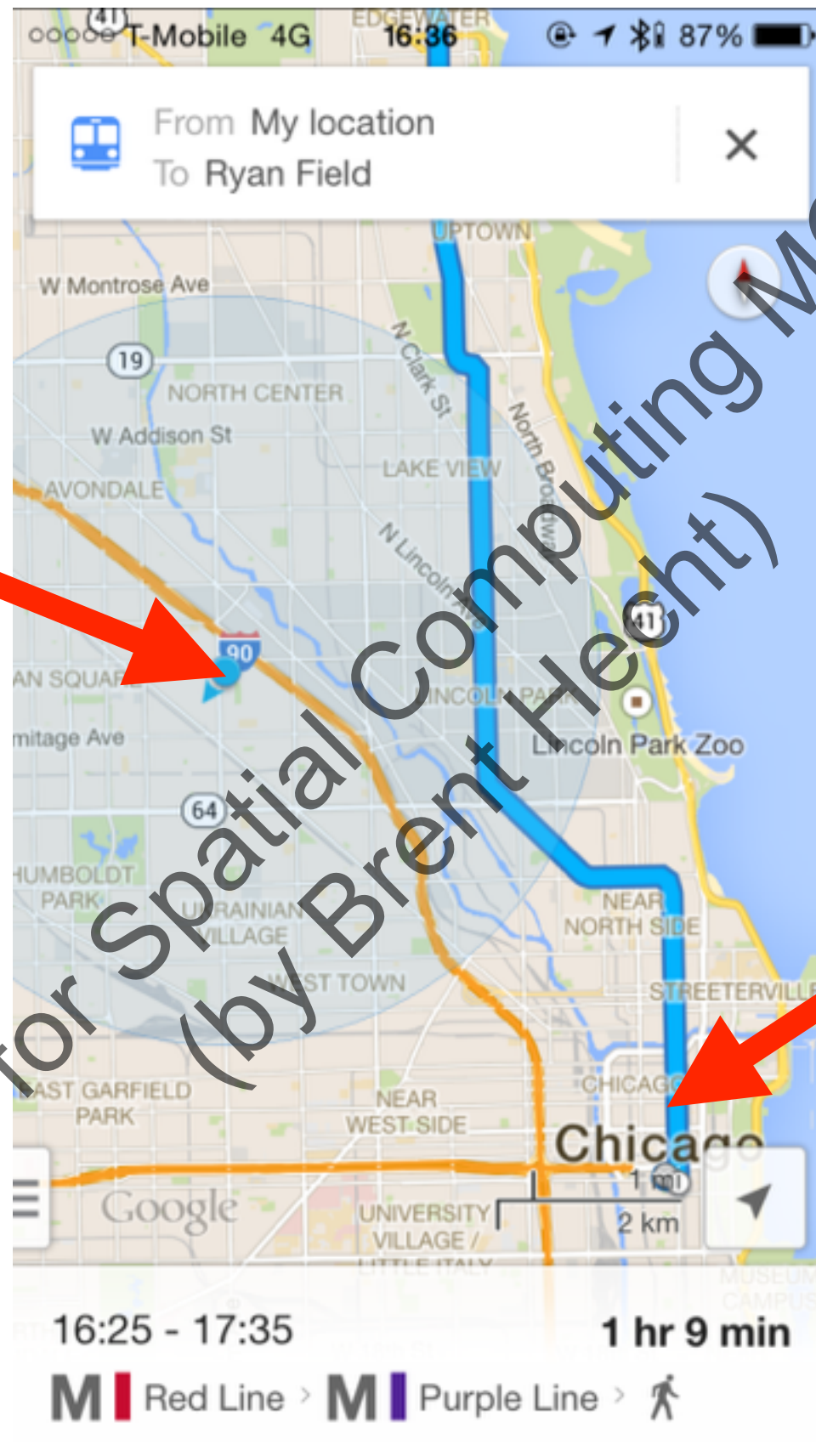


Wifi



Cell

Slides for Spatial Computing MOOC
(by Brent Hecht)





Slides for Spatial Computing MOOC
(by Brent Hecht)

Location-based advertising using subway positioning:





Subways



GNSS



Wifi



Cell



SubwayPS



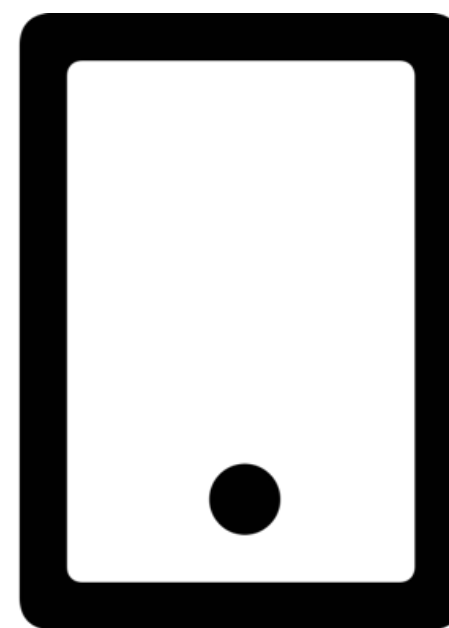
Sensors



Wifi Cell



Internet



Smartphone

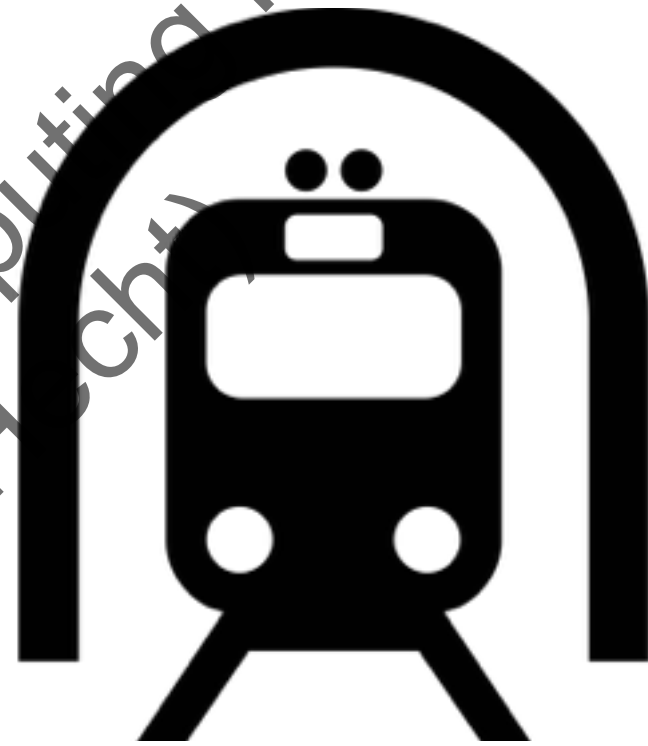
Slides for Spatial Computing MOOC (by Brent Hecht)

\$€¥£

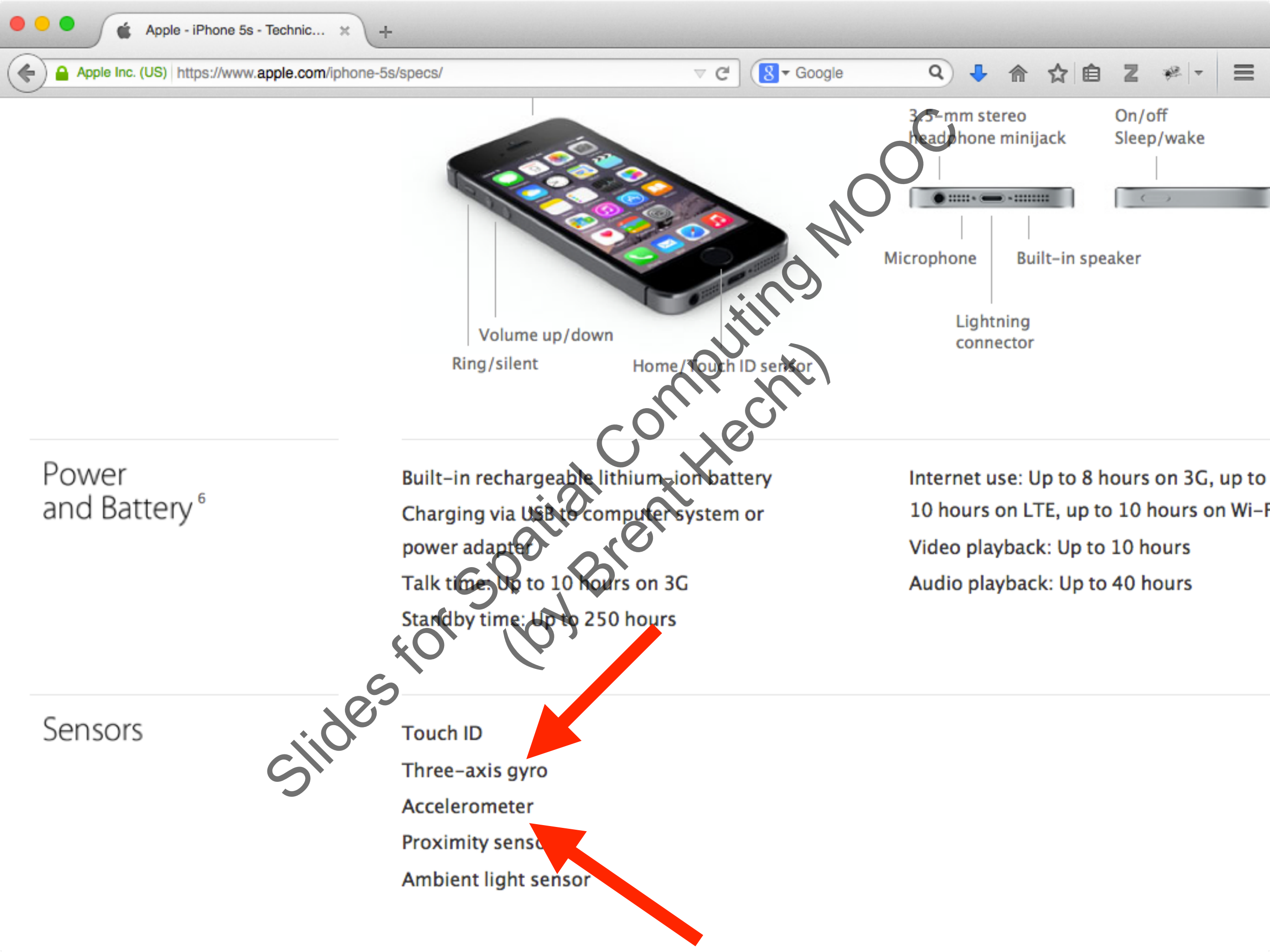




Not Moving



Moving



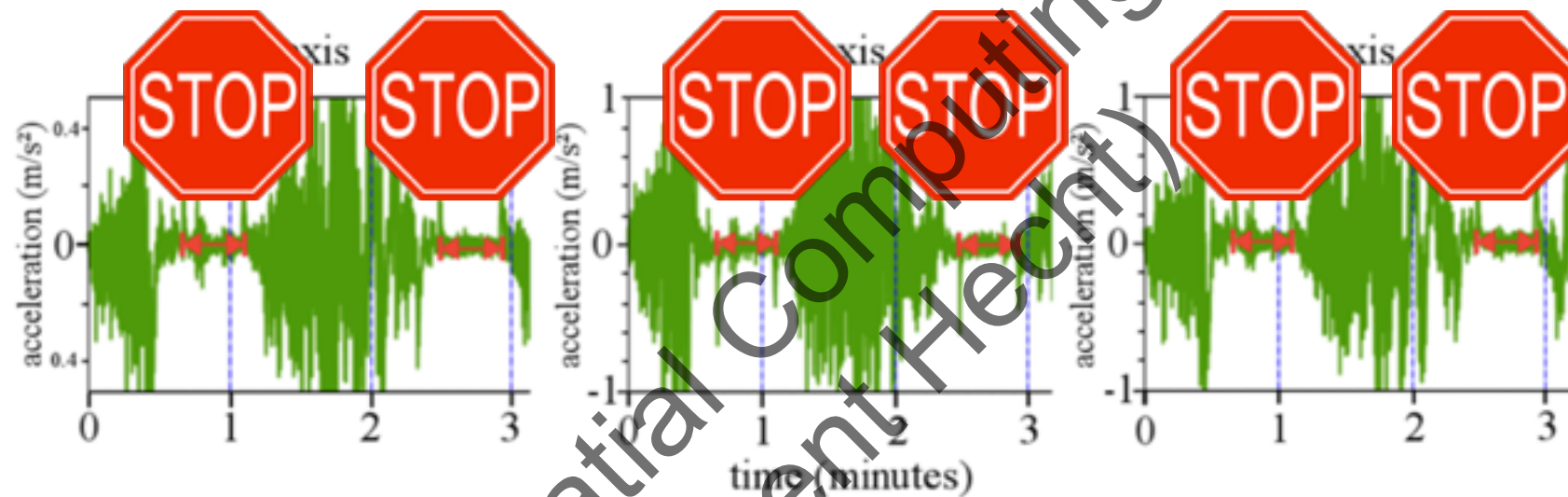
Power and Battery⁶

Built-in rechargeable lithium-ion battery
Charging via USB to computer system or power adapter
Talk time: Up to 10 hours on 3G
Standby time: Up to 250 hours

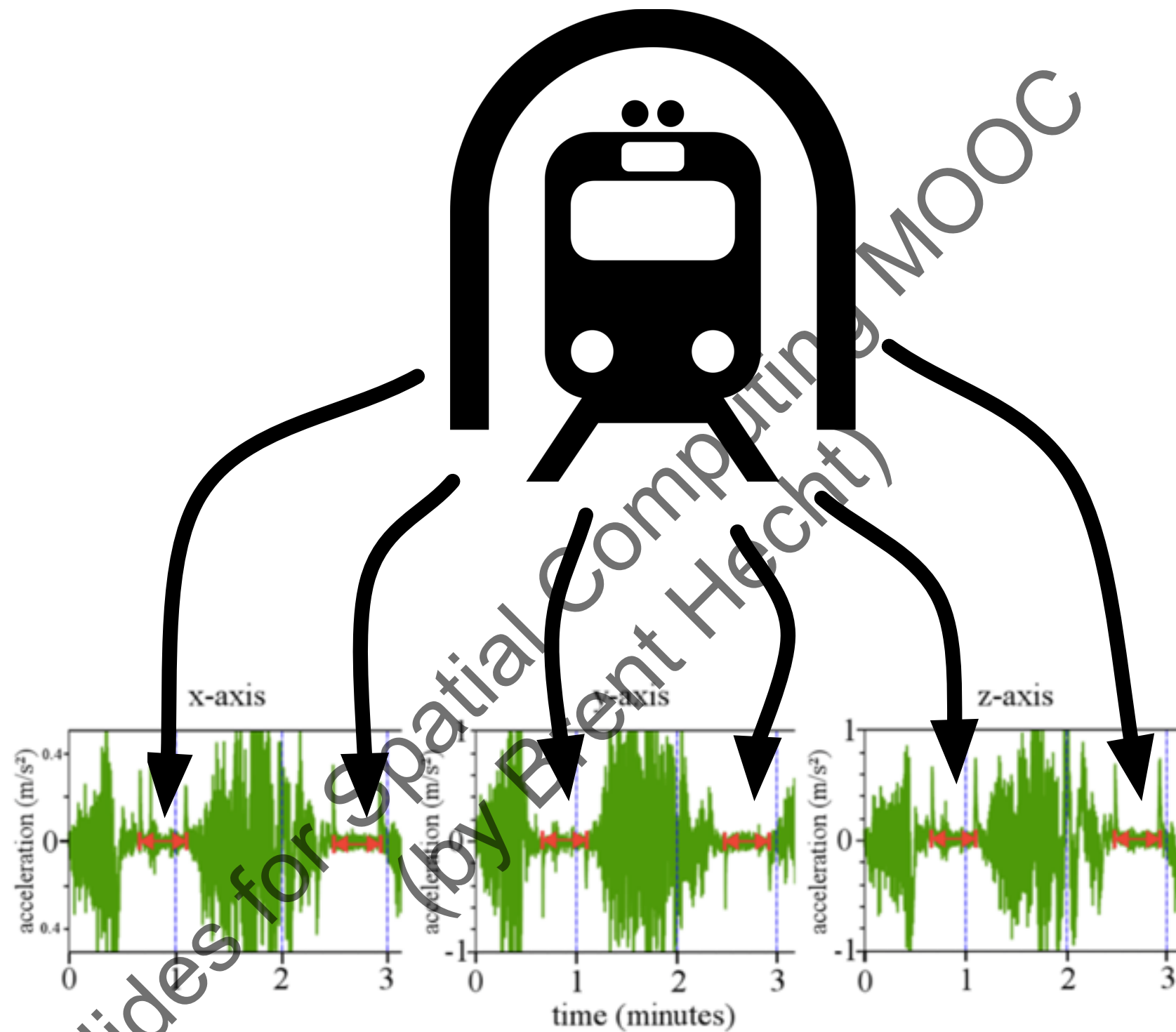
Internet use: Up to 8 hours on 3G, up to 10 hours on LTE, up to 10 hours on Wi-Fi
Video playback: Up to 10 hours
Audio playback: Up to 40 hours

Sensors

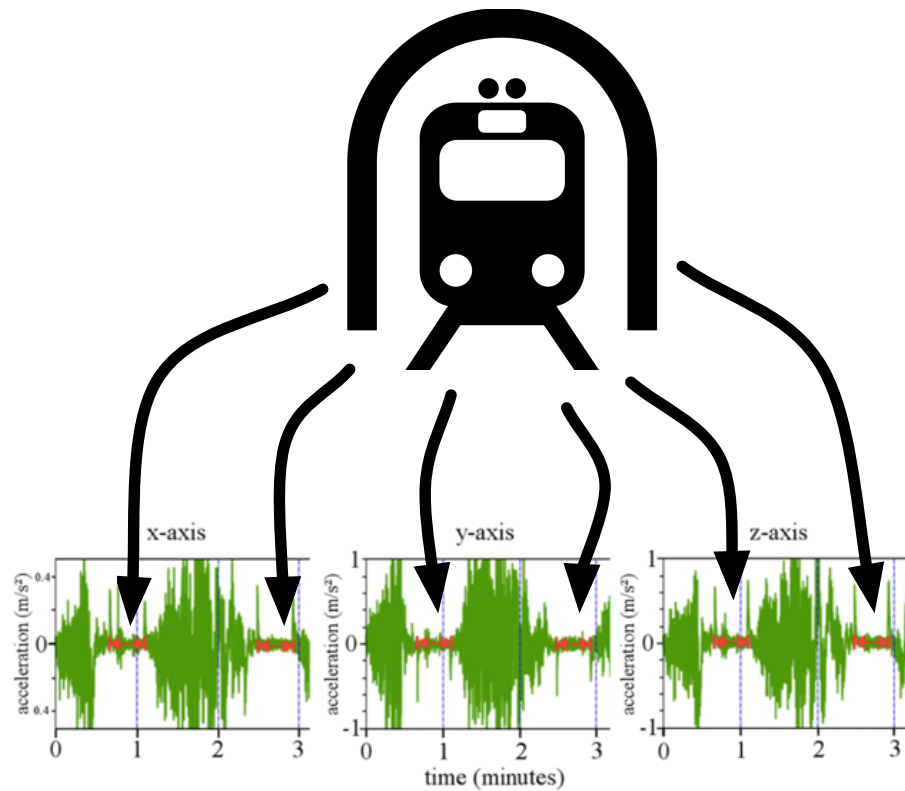
Touch ID
Three-axis gyro
Accelerometer
Proximity sensor
Ambient light sensor



Accelerometer readings from the
Central Line in London



Accelerometer readings from the
Central Line in London



Stop Detection

: Vincennes		Direction: Étoile		M 6 Étoile Nation
art	Dernier départ	Premier départ	Dernier départ	
	1:15	5:30	0:42	Nation Picpus Bel Air Daumesnil Dugommie Bercy Quai de la Chevaleret Nationale Place d'Italie Corvisart Glacière
	1:13	5:31	0:43	
	1:12	5:32	0:44	
	1:10	5:33	0:45	
	1:08	5:34	0:46	
	1:07	5:35	0:47	
	1:05	5:37	0:49	
	1:03	5:38	0:50	
	1:01	5:39	0:51	
	1:00	5:40	0:52	
	0:59	5:41	0:53	
	0:57	5:43	0:55	

Official Timetable

Smartphone Position

along a subway line

Stop Detection:

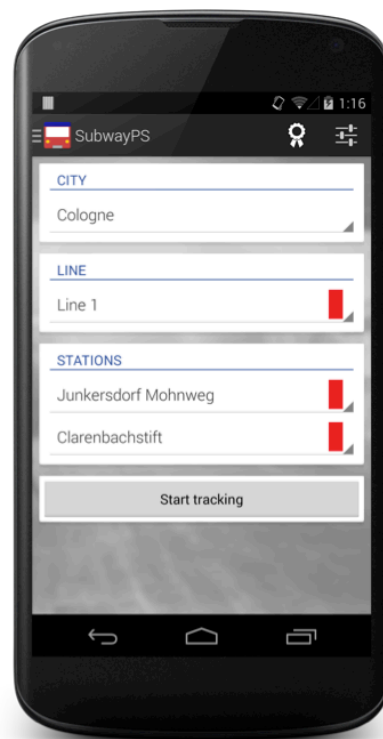
85% **accurate** across four
subway systems

Slides for Spatial Computing MOOC
(by Brent Hecht)

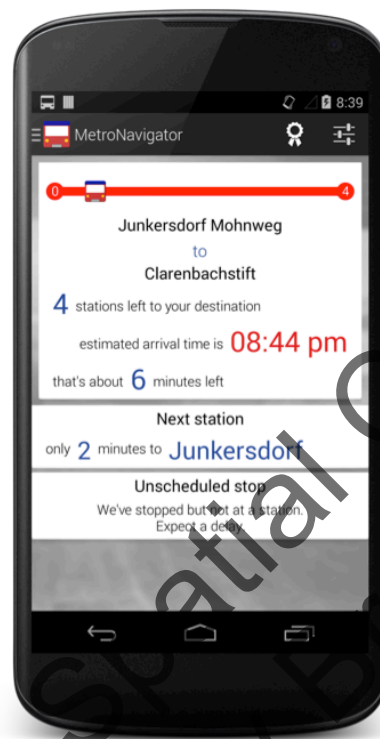
Whole Trip Accuracy:

78% of trips tracked
perfectly

42% baseline of using
timetable only



a)



b)

Unscheduled stop
We've stopped but not at a station.
Expect a delay. c)

Unexpected event d)
Oh, this is a bumpy ride and not so
smooth as normal. Maybe worth to
share? 

Point of interest e)
you're now crossing under
Cologne Cathedral
(Kölner Dom) 

MetroNavigator

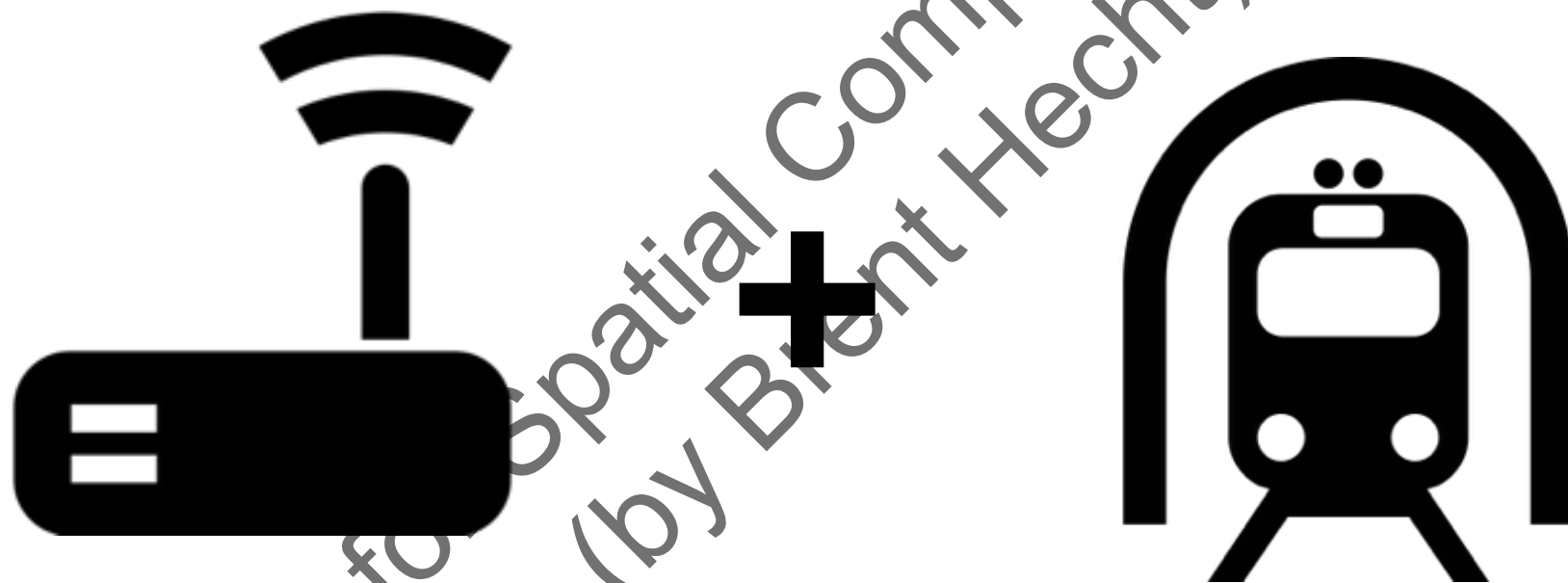


As my GPS does not work here, this is like a GPS for undergrounds trains – I want to have it integrated in Google Maps” (Participant 3)

“It is just cool to see the train moving and stopping on the map – I feel safer when I can see that we have stopped close to the next station when we’re stopped in the middle of a tunnel” (Participant 11)

Oops, it seems that the system missed a stop – that is not good. I would also be happy to help the system to detect the stops, if the system could help me to get out at the right station. That would be totally fine with me.” (Participant 3)

Future Work



Correcting for drift errors

Advances in Positioning

“SubwayPS: Towards Enabling Smartphone Positioning in Underground Public Transportation Systems”

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