

# Future of Computing and What Do We Do

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Wh ere?  
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April 30, 2020

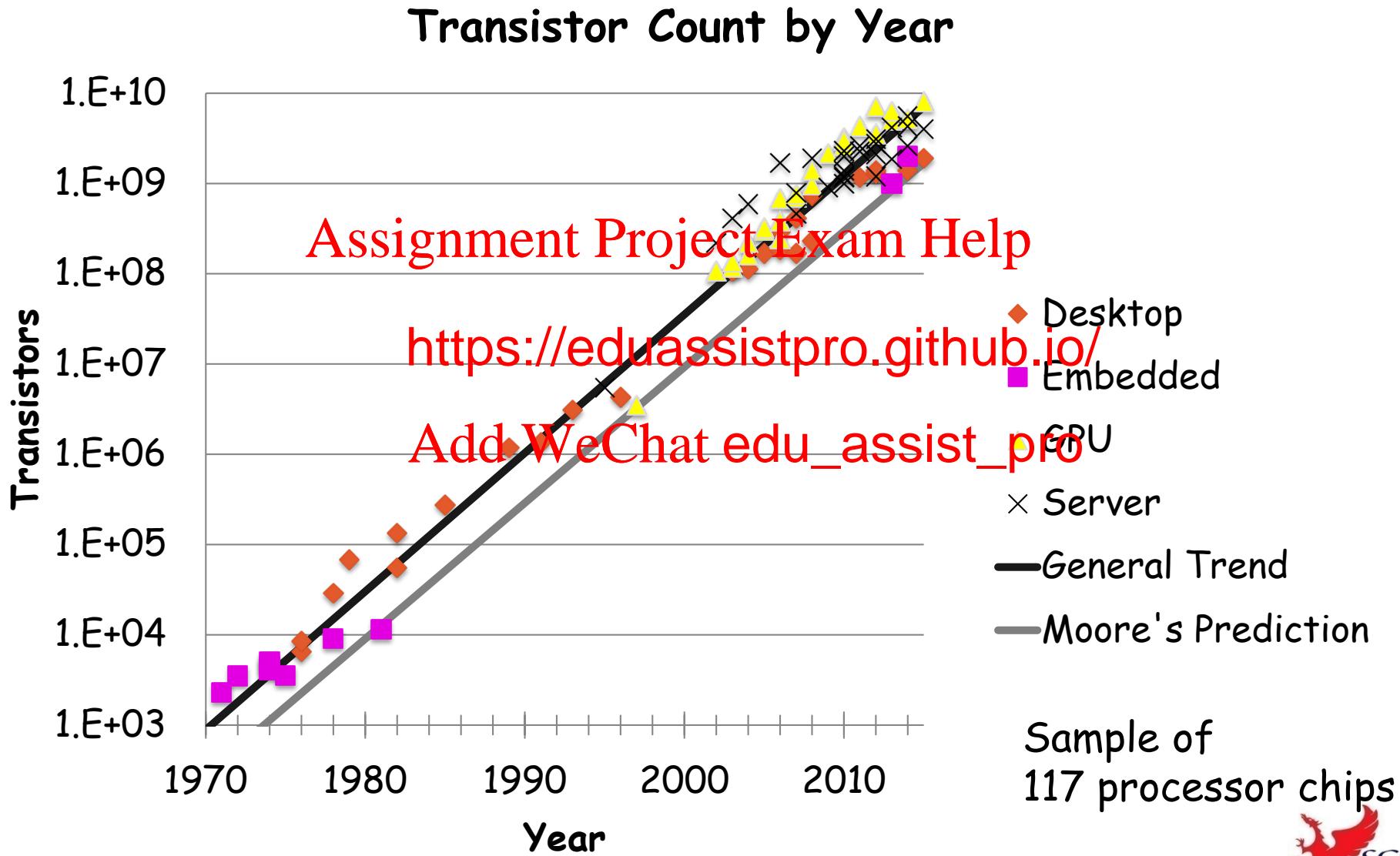
# Today

- Beyond Moore's Law
- Technology & Labor
- What is Money?  
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- 213 Final  
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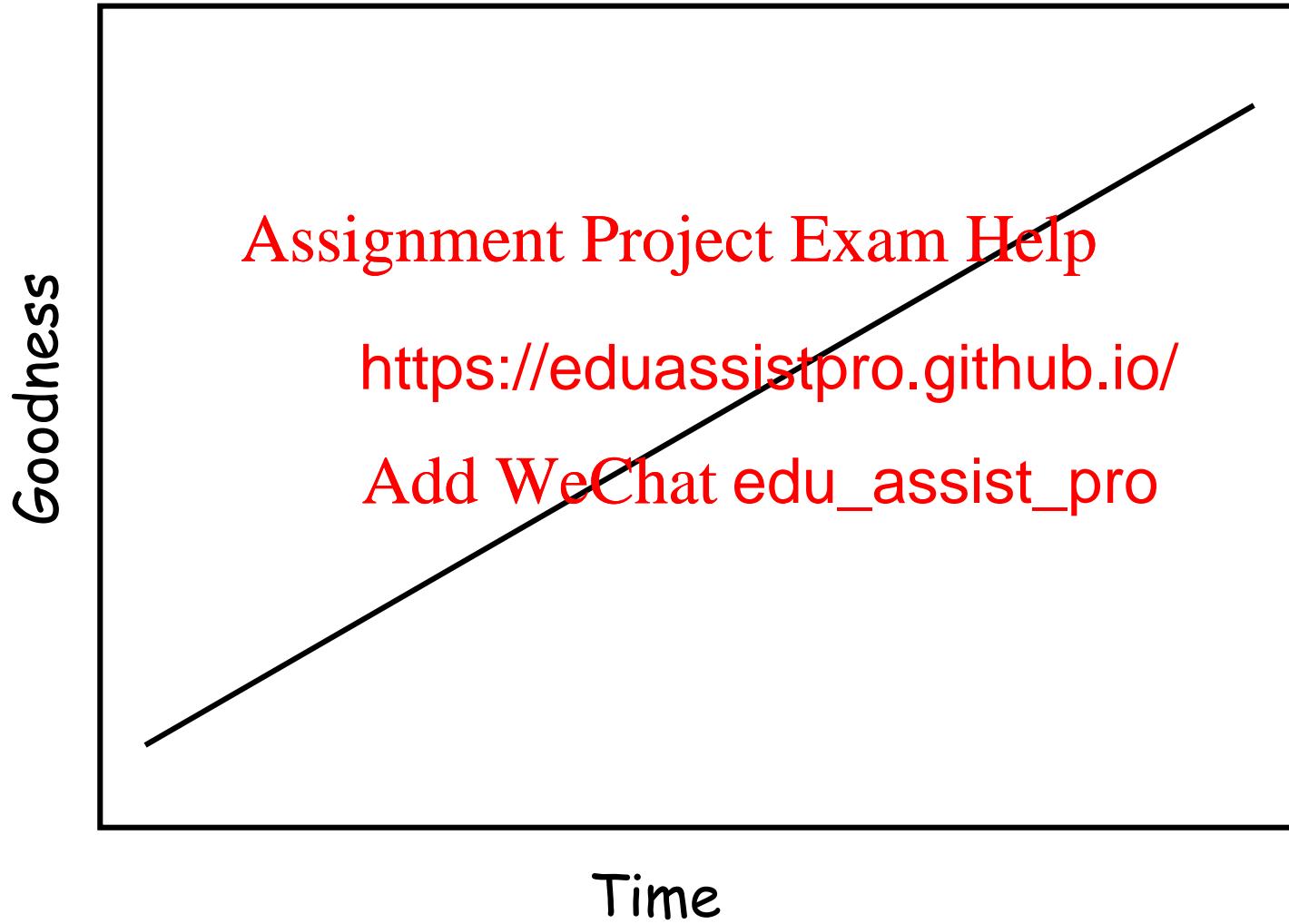
# Moore's Law Origins

- Moore's Thesis
  - Minimize price per device
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- Optimum number of  
es / chip increasing  
<https://eduassistpro.github.io/>
- 1965: 5
- 1970: 1000
  - 2x / 2 years
  - "Moore's Prediction"

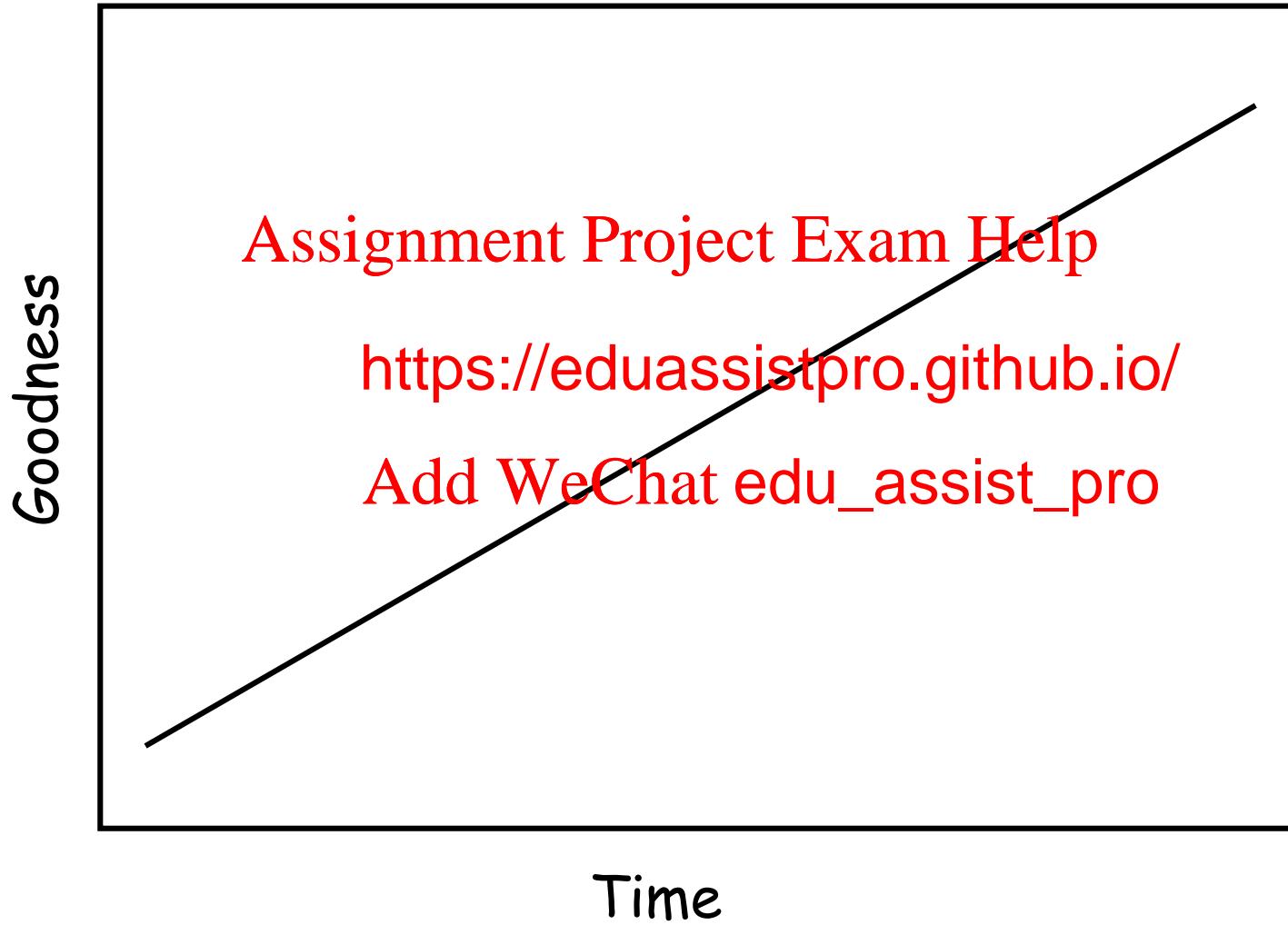
# Moore's Law: 50 Years



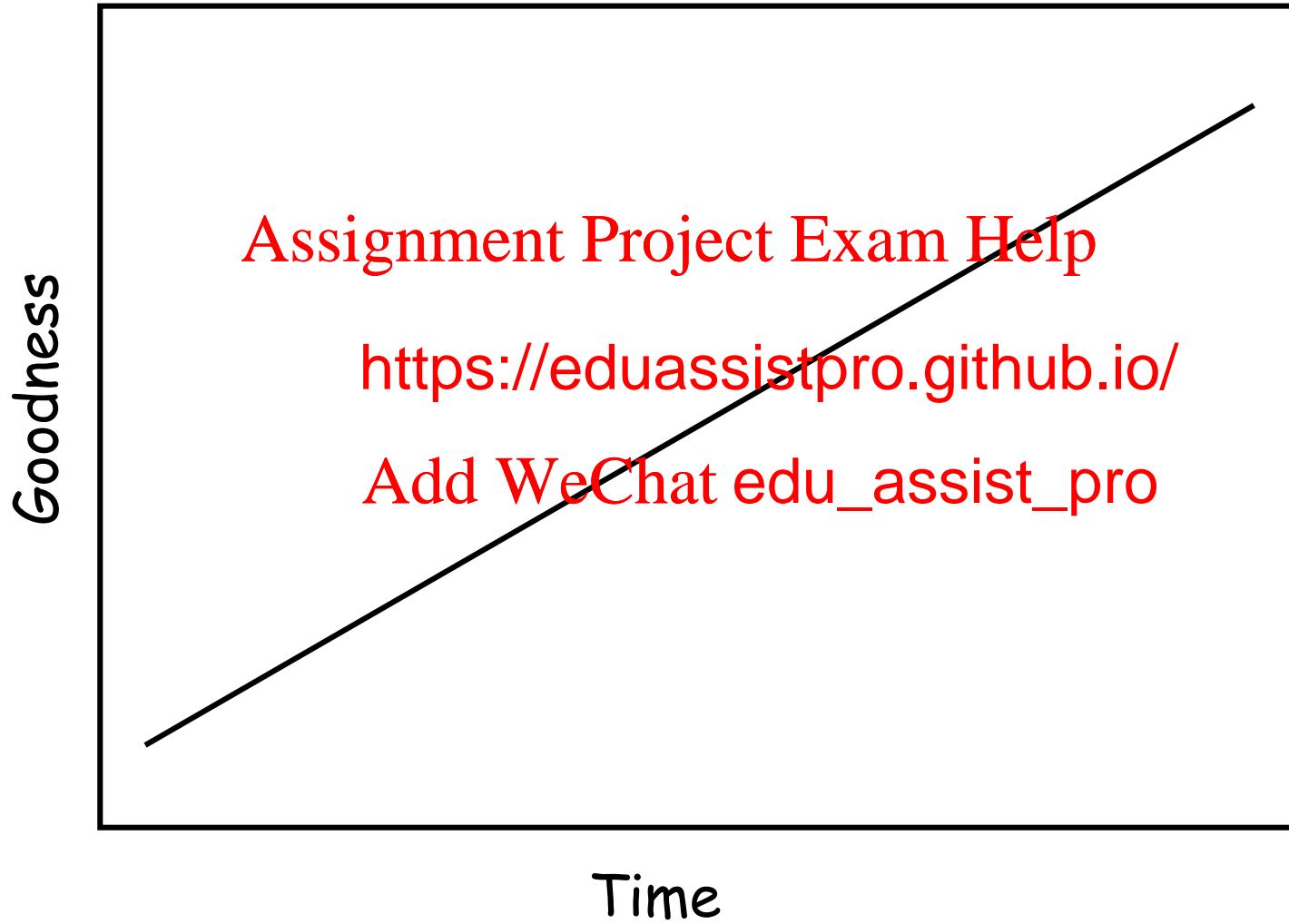
# Moore's Law



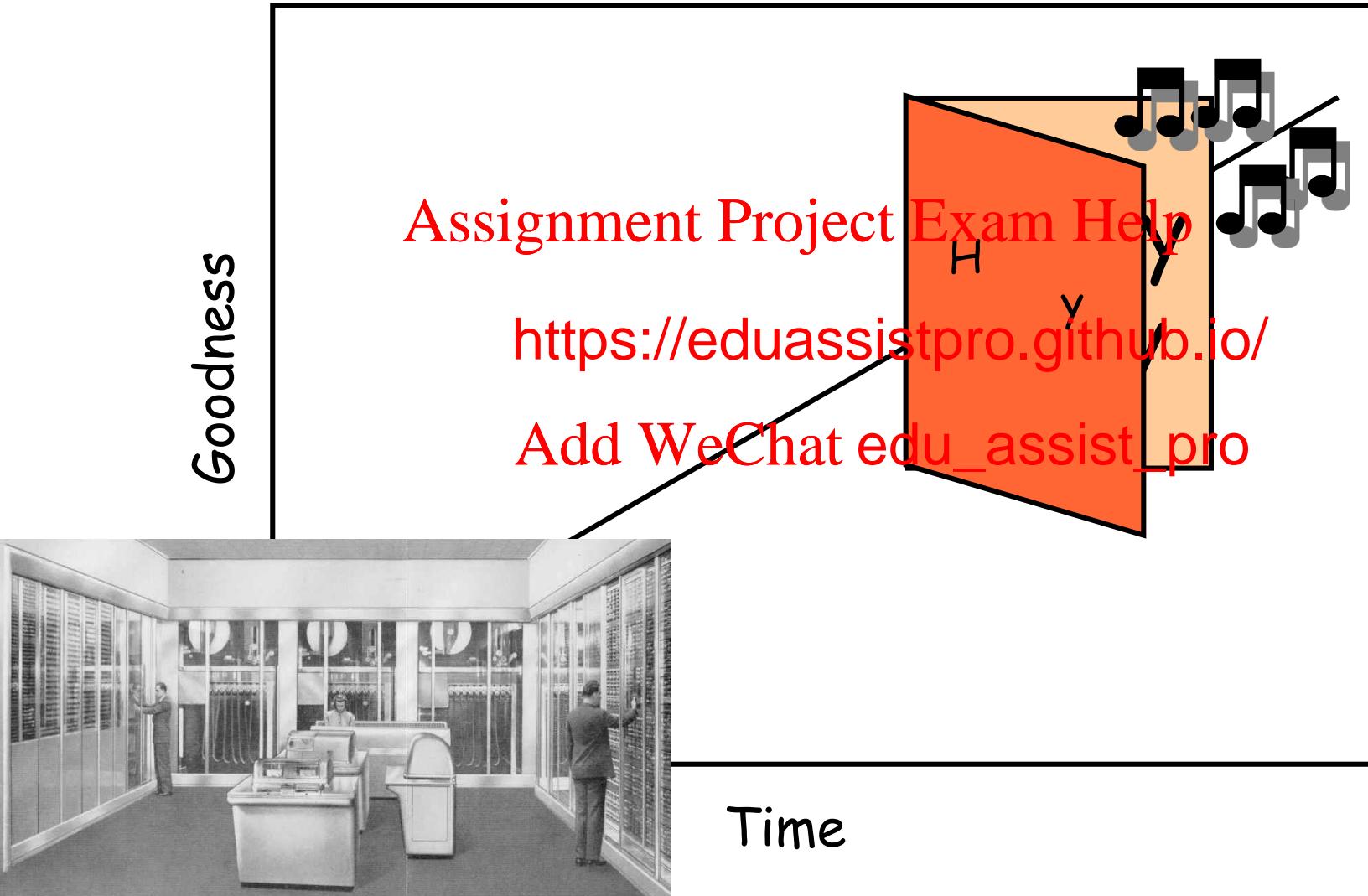
# Moore's Law



# Moore's Law



# Moore's Law



# Eniac → PS/4

- How much would enough Eniac's weigh to equal 2.8Kg of PS/4 computing?

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# Eniac → PS/4

- How much would enough Eniac's weigh to equal 2.8Kg of PS/4 components?



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Alternatively, more than all the buildings in Pittsburgh!

# Eniac → PS/4

- From 1946 to 2014

	Eniac	PS/4	Improvement
Ops/sec	$3 \times 10^3$	$10^{10}$	$10^6$
Cost	A	<a href="https://eduassistpro.github.io/">https://eduassistpro.github.io/</a>	
Power	$10^{24}$ ops/sec	Add WeChat edu_assist of	
Volume		m <sup>3</sup> -W	
Weight	$2.7 \times 10^5$ Kg	2.8 Kg	$10^5$

# Understanding Exponentials

- Key to future forecasting
- Very Very hard for humans to do

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# Understanding Exponentials

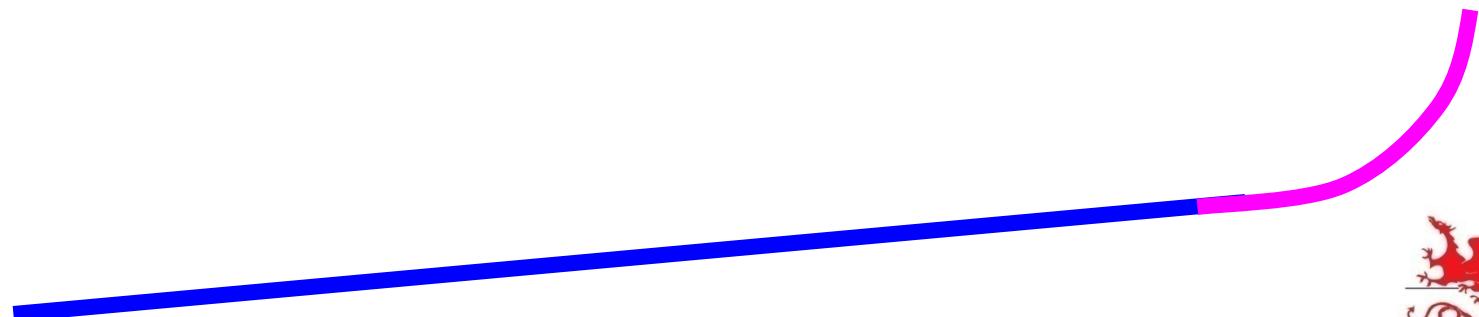
- Key to future forecasting
- Very Very hard for humans to do
- Example: Kasparov Vs Deep Blue
  - 1989: Kep blue  
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# Understanding Exponentials

- Key to future forecasting
- Very Very hard for humans to do
- Example: Kasparov Vs Deep Blue  
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  - 1989: K
  - 1996: D

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me](https://eduassistpro.github.io/me)  
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# Understanding Exponentials

- Key to future forecasting
- Very Very hard for humans to do
- Example: Kasparov Vs Deep Blue
  - 1989: K
  - 1996: D
  - 1997: Deep Blue win

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ep blue  
me

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enf

# Understanding Exponentials

- Key to future forecasting
- Very Very hard for humans to do
- Example: Kasparov Vs Deep Blue
  - 1989: K
  - 1996: D
  - 1997: Deep Blue win
- Particularly hard in the beginning

# What Moore's Law Has Meant



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- 1976 Cray 1

- 250 M Ops/second
- ~170,000 chips
- 0.5B transistors
- 5,000 kg, 115 KW
- \$9M
- 80 manufactured

- > 10 B Ops
  - 16 chips
  - 4.3B transistors
  - 174 g, < 1W
  - \$999
  - ~3 million
- + Camera
  - + GPS
  - + Microphone
  - + Wireless
  - + graphics
  - + + + + +

# What Moore's Law Has Meant

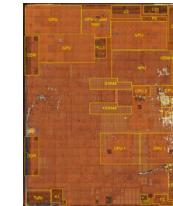
- 1965 Consumer Product
- 2017 Consumer Product

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Apple A11 Processor  
4.3B transistors

# What Moore's Law Could Mean

- 2017 Consumer Product
- 2065 Consumer Product

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- Low power
- Will drive markets & innovation

# Using All Those Transistors

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# Insatiable Demand for Computing

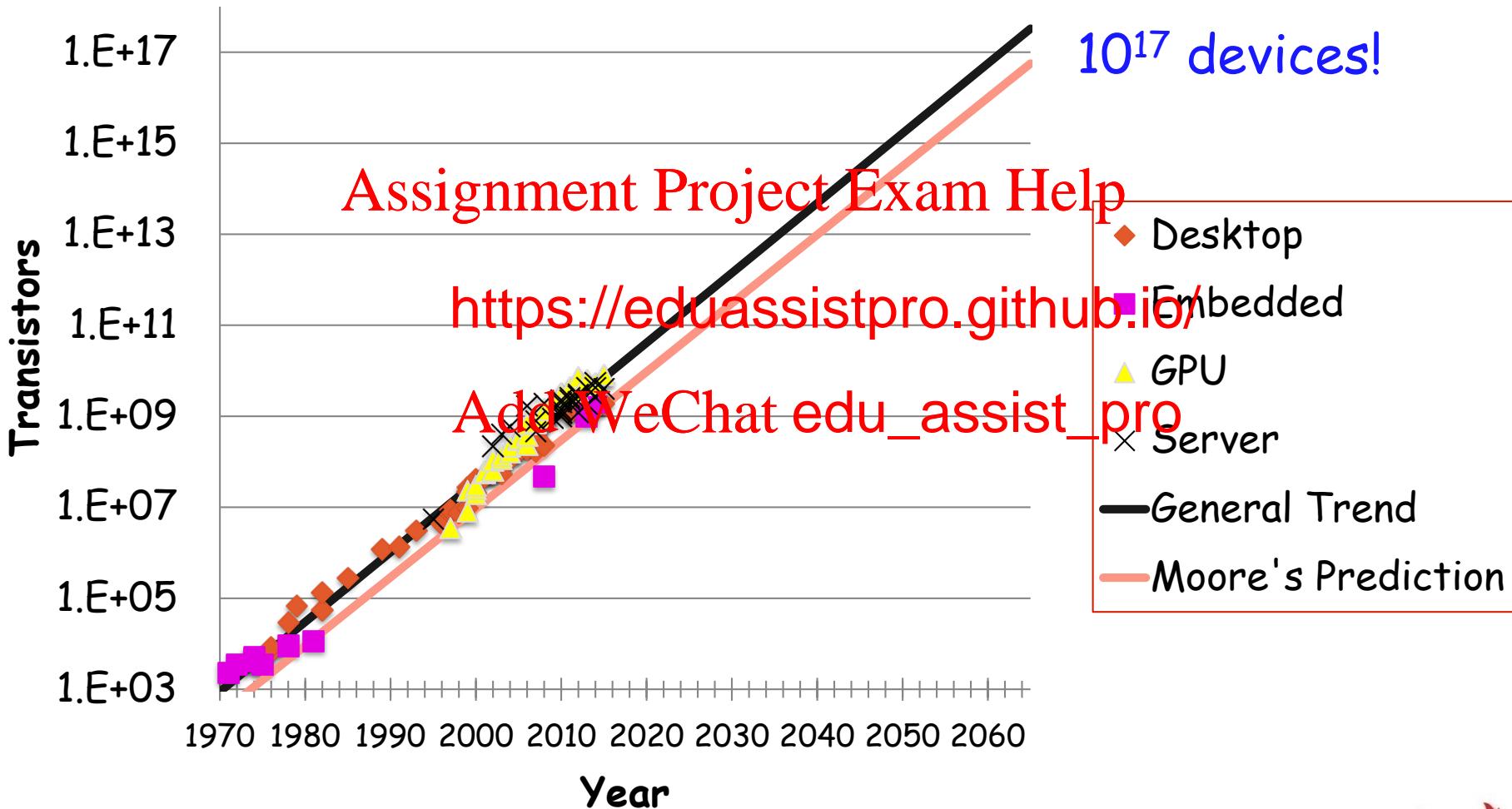
- Programmable matter?
- Simulating life
- Augmented Reality  
[Assignment](#) [Project](#) [Exam](#) [Help](#)
- Many ma <https://eduassistpro.github.io/>  
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# Requirements for Future Technology

- Must be suitable for portable, low-power operation
  - Consumer products
  - Internet of Things components
  - Not cryogenic
- Must be inexpensive
  - Comparable to <https://eduassistpro.github.io/> technology
    - $O(1)$  cost to make
- Need not be based on transistors
  - Memristors, carbon nanotubes, DNA transcription, ...
  - Possibly new models of computation
  - But, still want lots of devices in an integrated system

# Moore's Law: 100 Years

## Device Count by Year

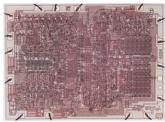


# Chips Have Gotten Bigger

NVIDIA GV100 Volta  
2017  
21.1 B transistors  
815 mm<sup>2</sup>

Intel 4004  
1971

2,300 transistors  
12 mm<sup>2</sup>



Apple A11  
2017  
4.3 B transistors  
89 mm<sup>2</sup>

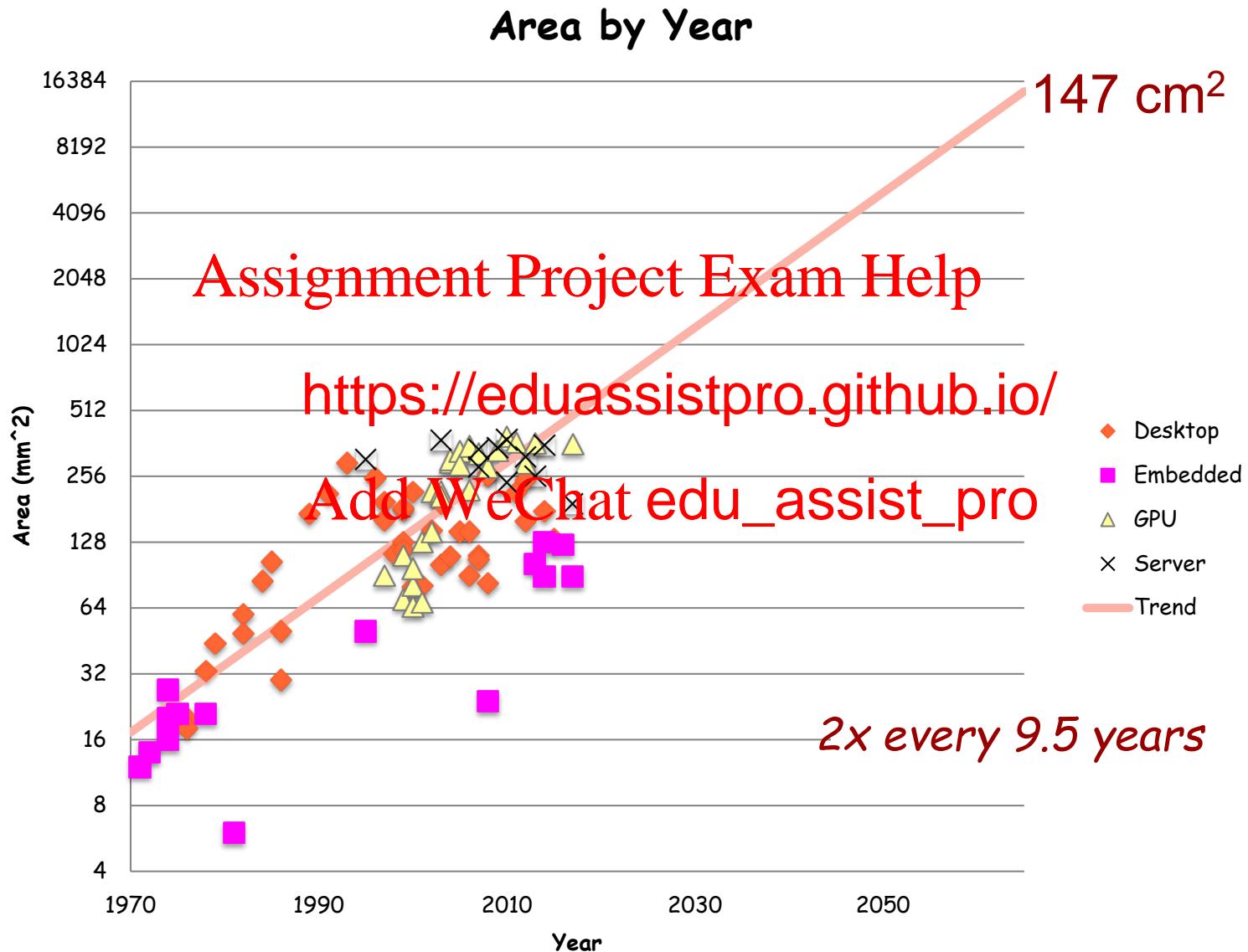


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# Chip Size Extrapolation



# Extrapolation: The iPhone XXX

Apple A59

2065

$10^{17}$  transistors

147 cm<sup>2</sup>

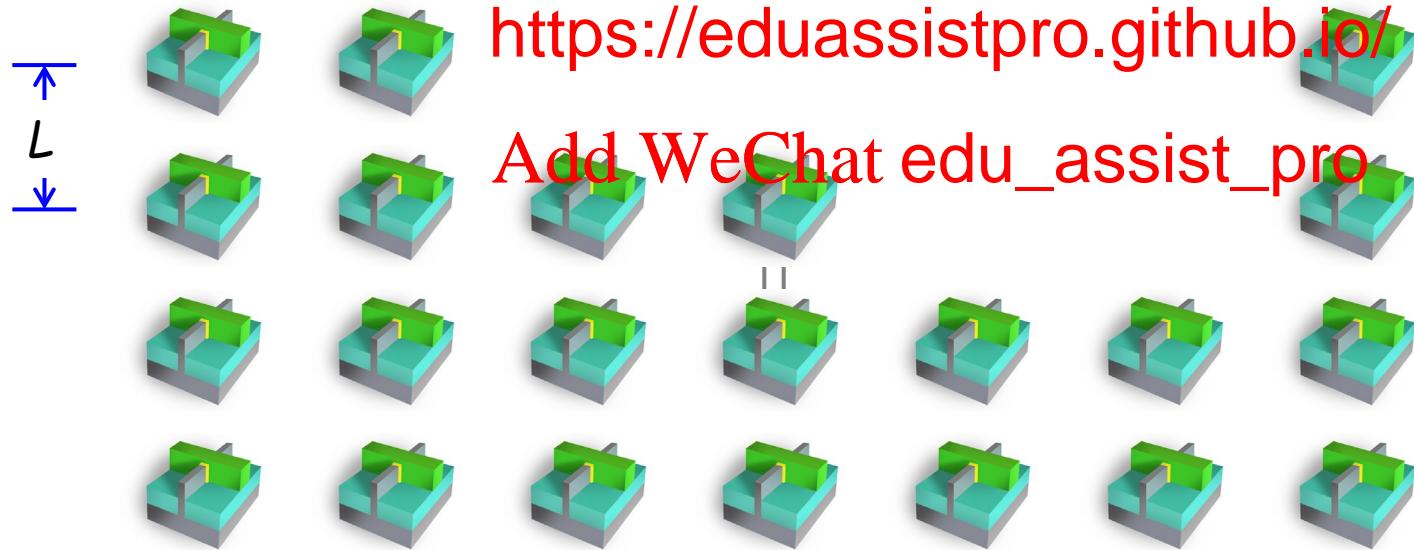
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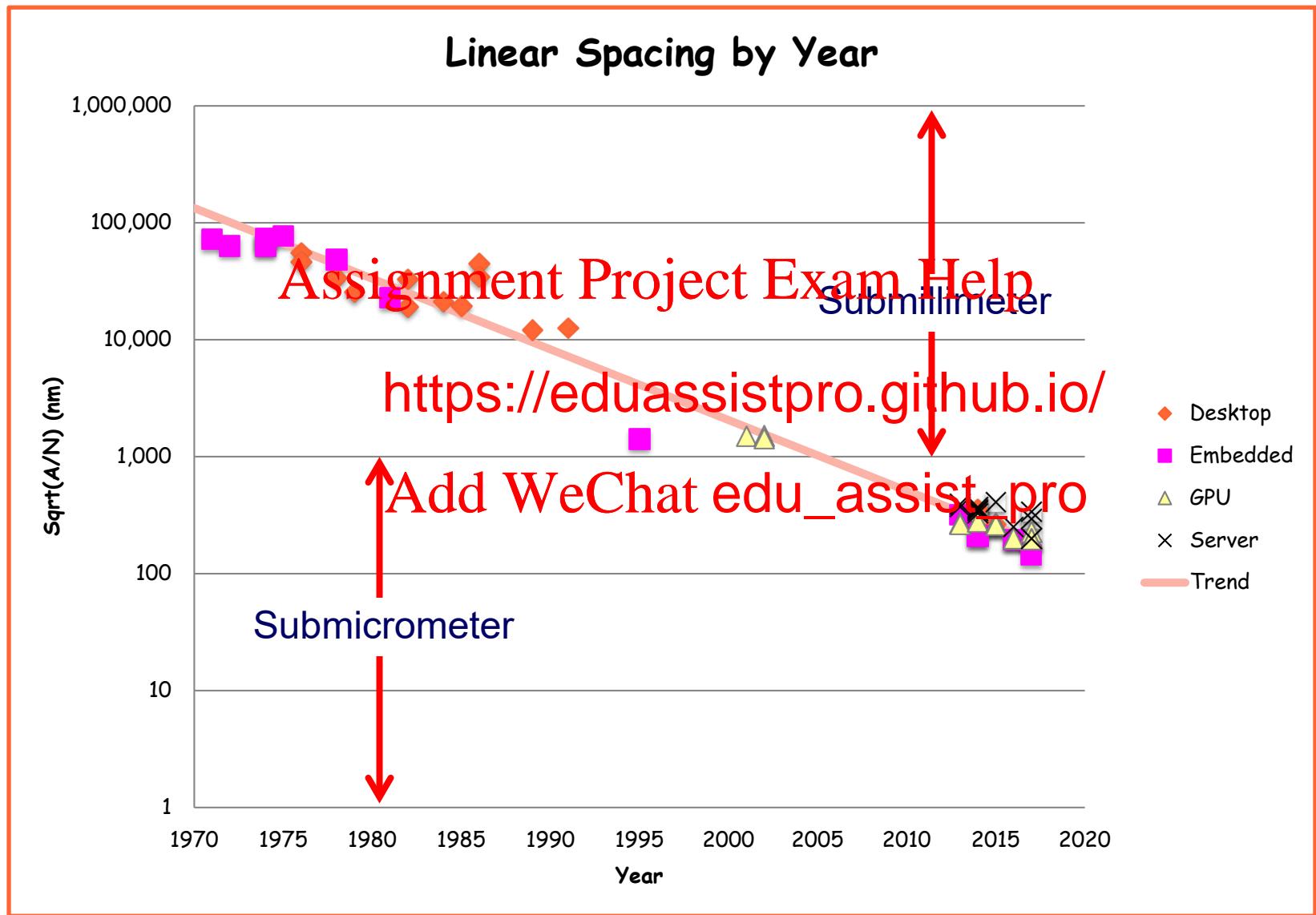
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# Transistors Have Gotten Smaller

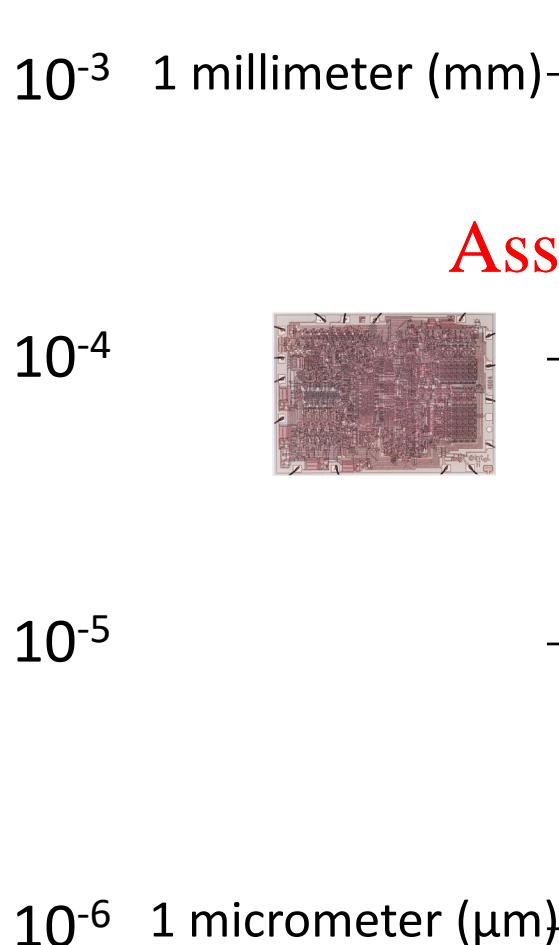
- Area  $A$
- $N$  devices
- Linear ~~Assignment~~ Project Exam Help



# Linear Scaling Trend



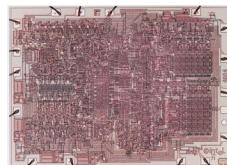
# Submillimeter Dimensions



500 $\mu\text{m}$ : Length of amoeba



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in human body

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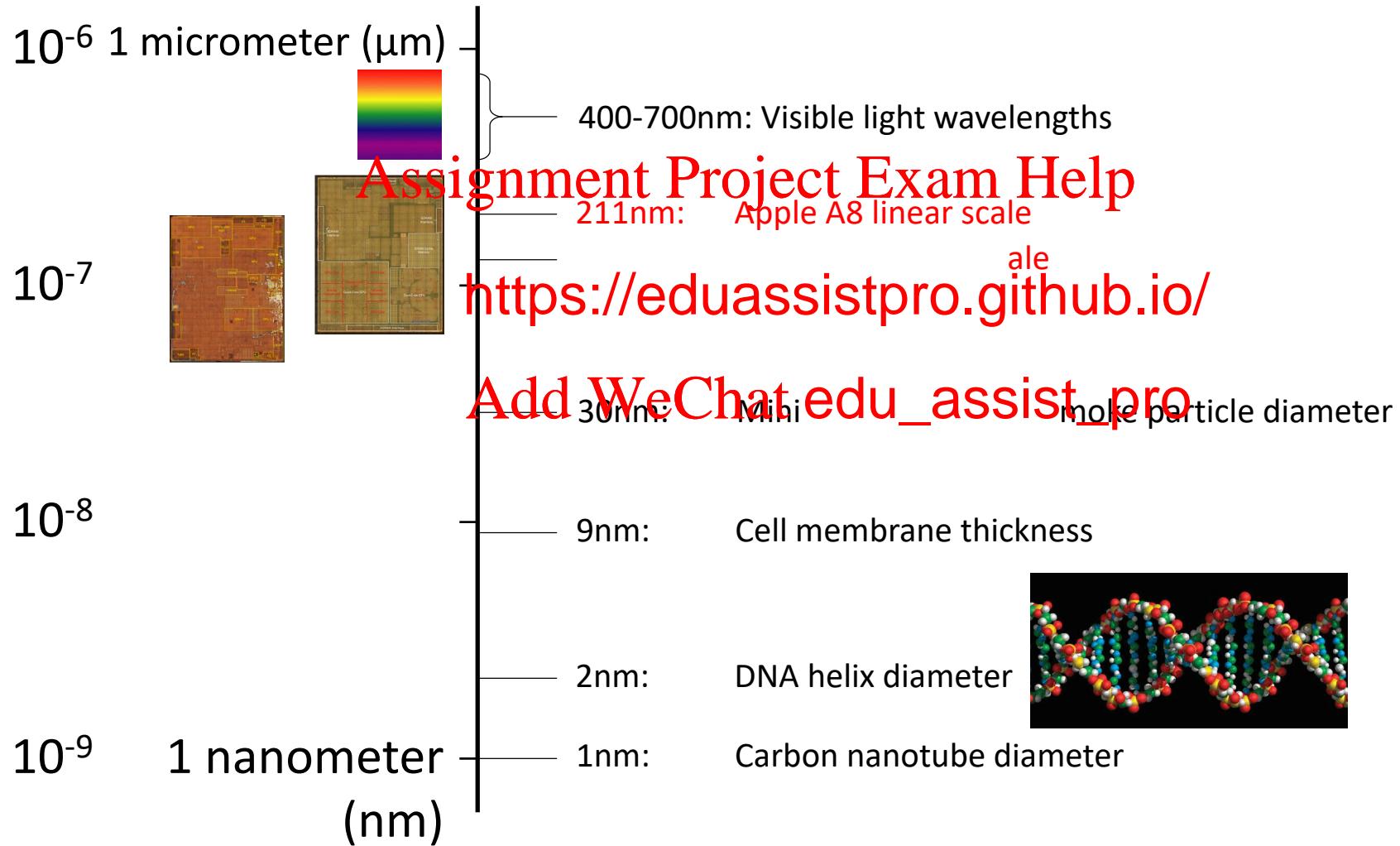
10 $\mu\text{m}$ : Thickness of sheet of plastic food wrap

5 $\mu\text{m}$ : Spider silk thickness

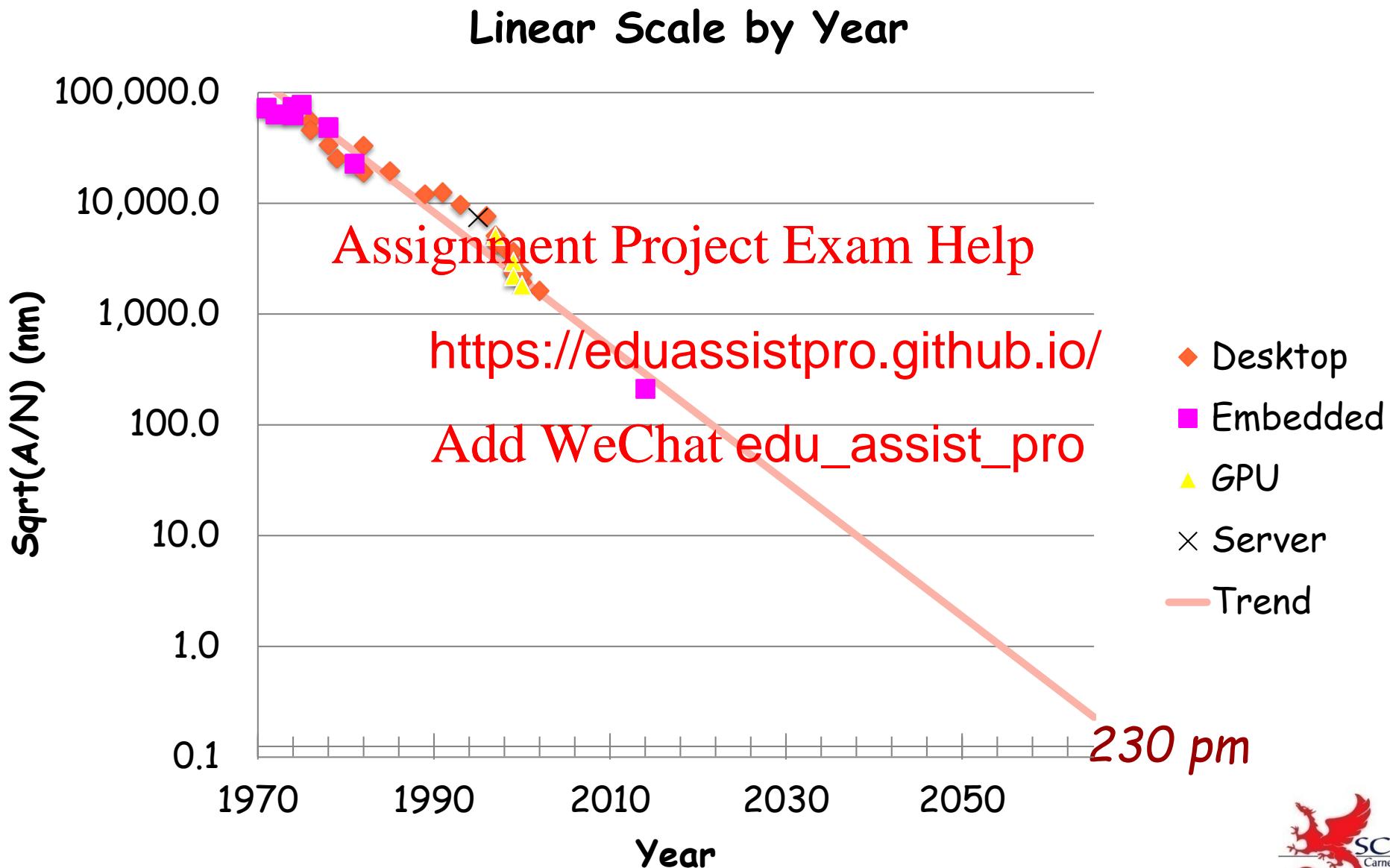
2 $\mu\text{m}$ : E coli bacterium length



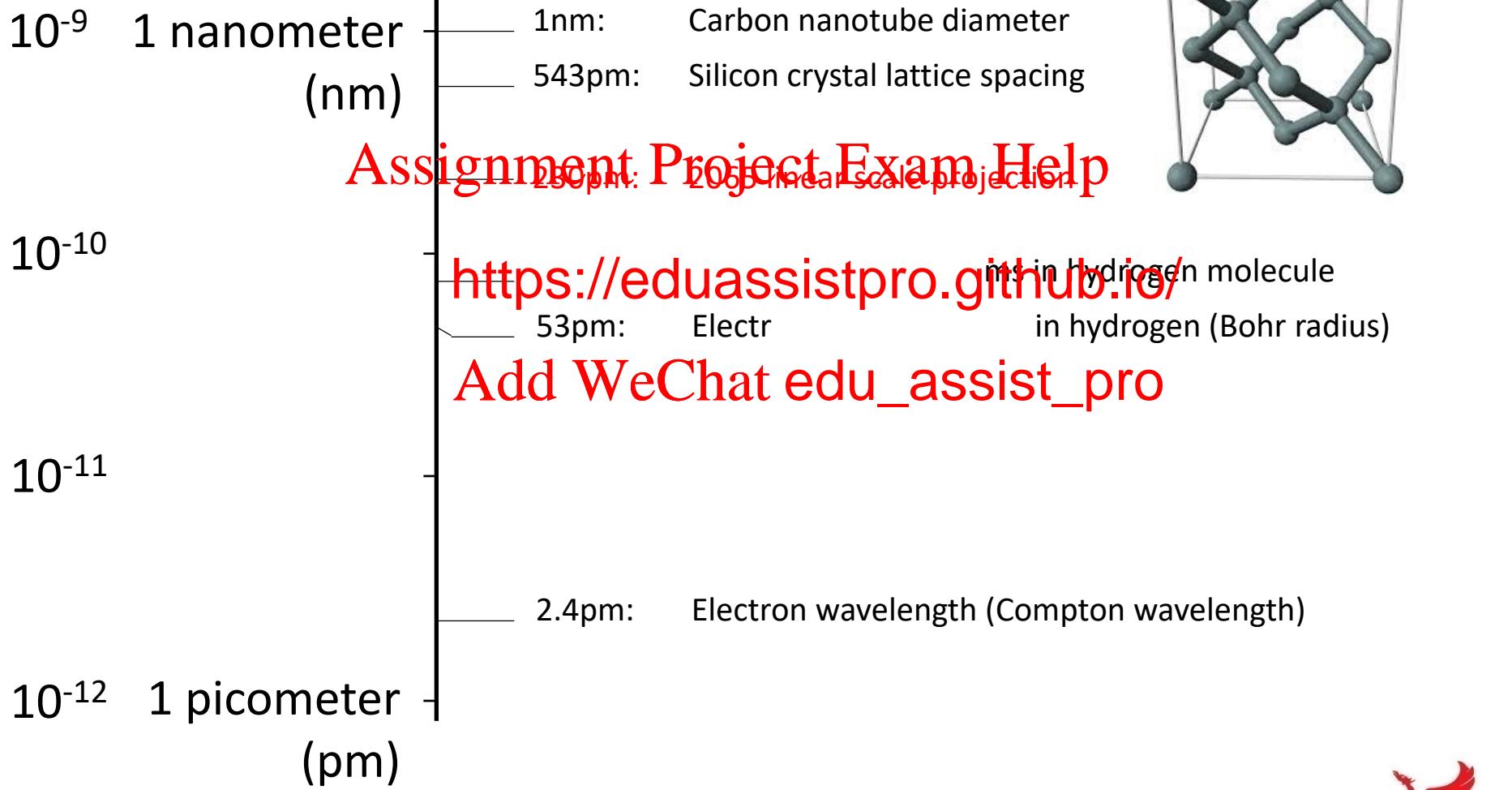
# Submicrometer Dimensions



# Linear Scaling Extrapolation



# Subnanometer Dimensions



# Pause for a second

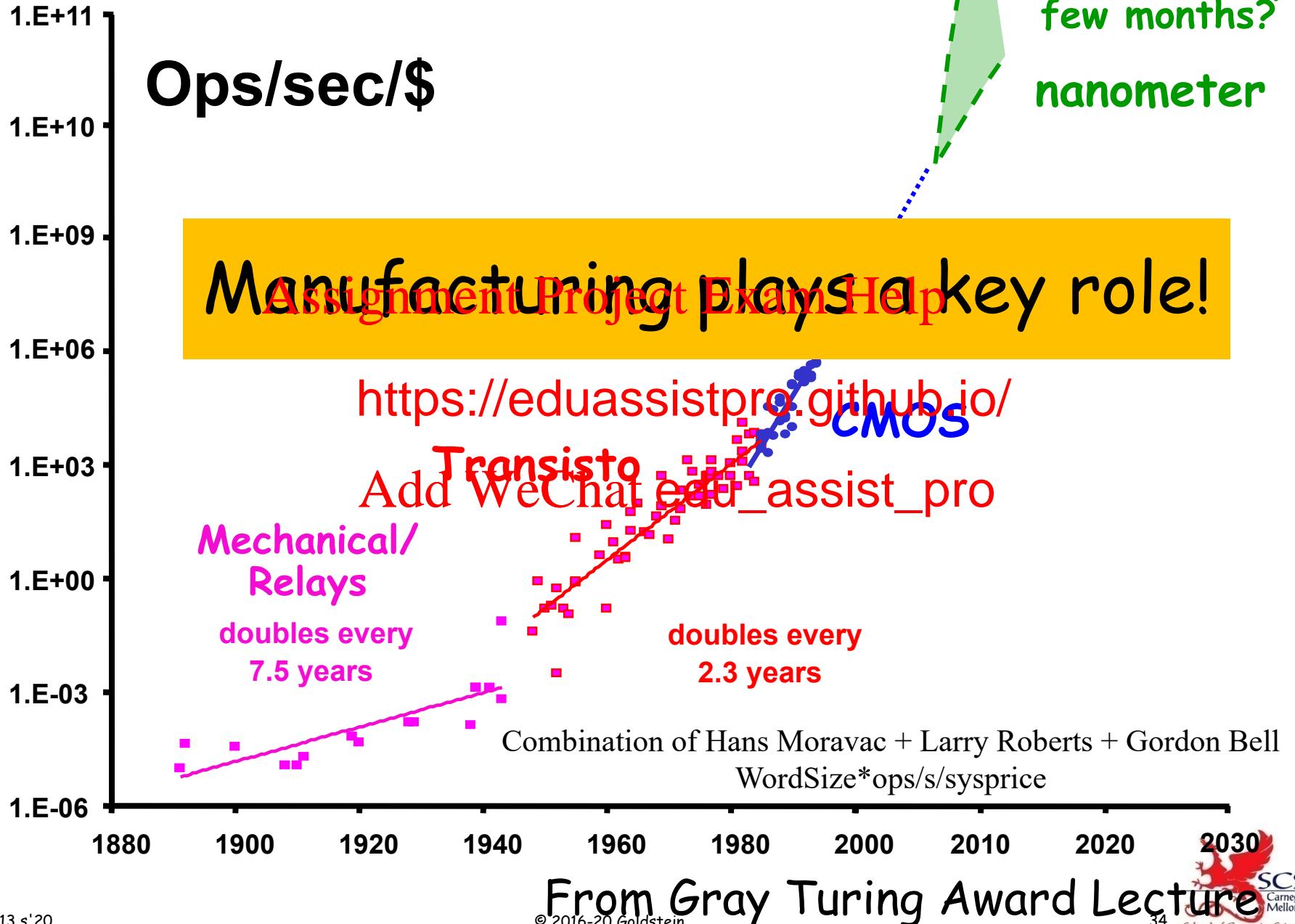
- 50 more years of Moore's law?
  - Probably not in Si, but ...
- Probably need new architectures, etc.  
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- But, so far,  
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Necessity is the mother of invention

# What Comes Next?



# What This Means for You

- As Computer users and Scientists?  
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- As People?

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# Great Reality

- More Heterogeneity

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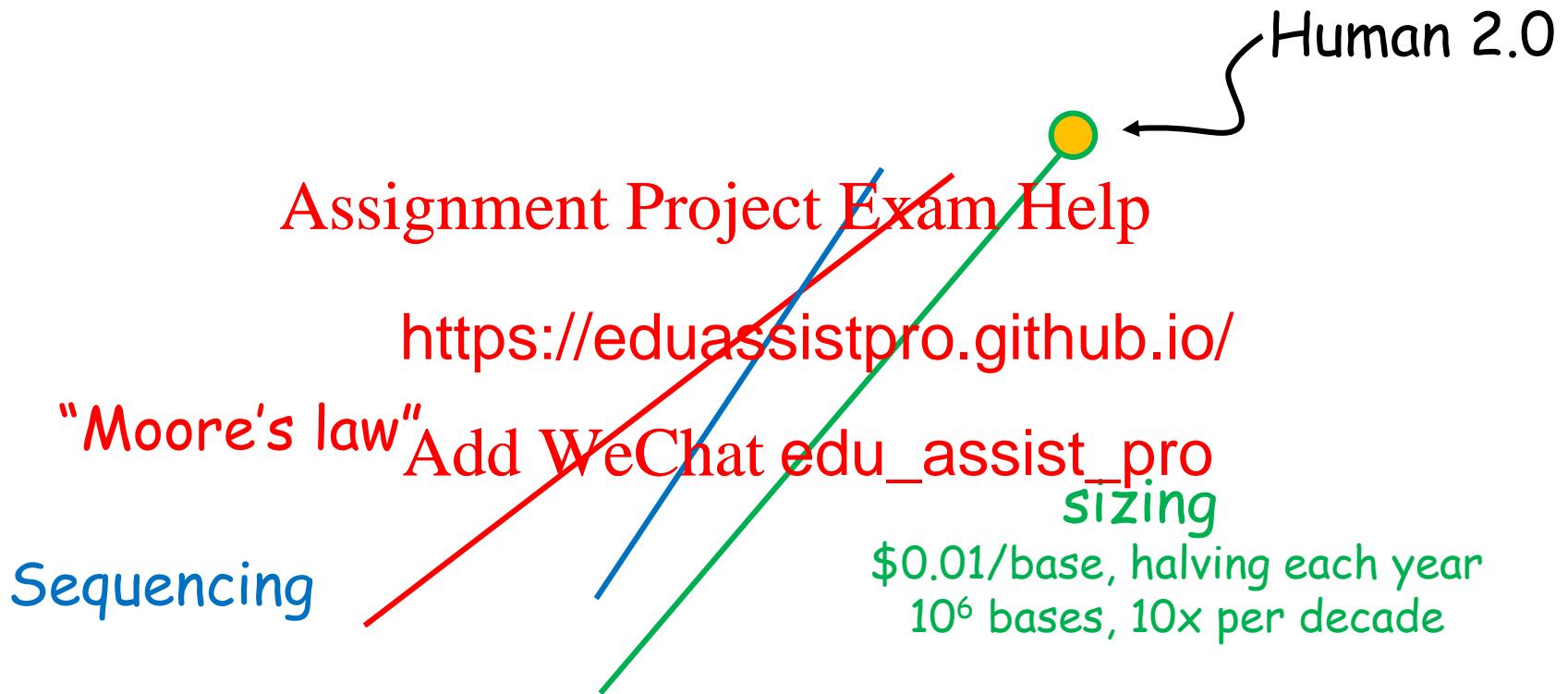
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- Centers of Boards  
of Chips Add WeChat edu\_assist\_pro
  - Cores
  - GPUs
  - FPGAs
- Lots of Concurrency

# Exponentials

- Moore's Law
- Biology
- Big Data/AI  
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- Manufact  
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  - Computi
  - Synthetic Biology
  - Additive Manufacturing
- Robotics
- Energy

# Exponentials Abound



# Big Data can look like AI



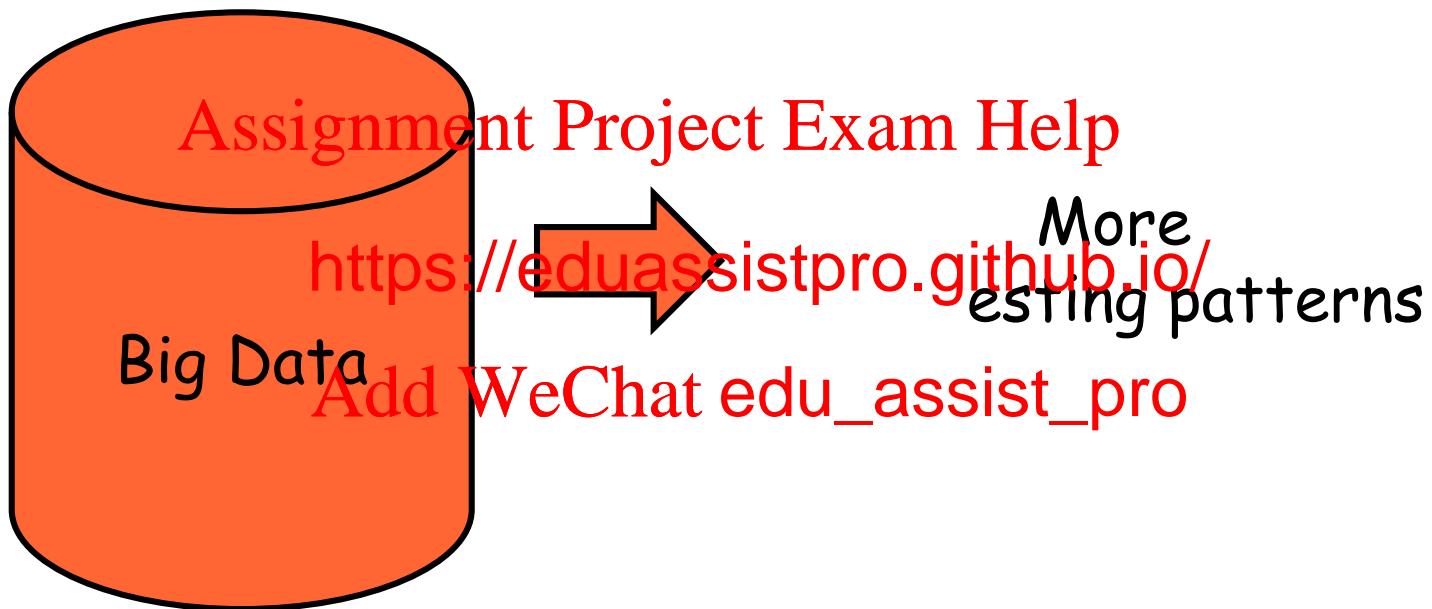
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Big Dat

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<https://eduassistpro.github.io/patterns>

# Big Data can look like AI



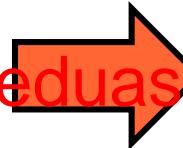
# Big Data can look like AI



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Even Big  
Big Data

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erns that look like  
activity/Intelligence  
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# What is your prediction?

AI-ish?

From Forbes.com:

Despite an expected dip in profit, analysts are generally optimistic about Fluor as it prepares to reports its first quarter earnings on Thursday, May 1, 2014. The estimate is 96 cents per share

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1.E+05

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"WISCONSIN appears to be in the driver's seat en route to a win, as it leads 51-10 after the third quarter. Wisconsin added to its lead when Russell Wilson found Jacob Pedersen for an eight-yard touchdown to make the score 44-3 ...."

1987

2011

# Exponentials

- Moore's Law
- Biology
- Big Data/AI  
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- Manufact  
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  - Computi
  - Synthetic Biology
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- Robotics
- Energy

# The World is Changing

- Technology Trends

- Nanotechnology      Clean ubiquitous Cheap Energy
- Synthesis      More Knowledge available to more people
- Computers      Assignment Project Exam Help  
                         Safer & Faster travel
- Robotics      <https://eduassistpro.github.io/> playing field

- Some Implications

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zed anything

- What Should We Do?

Better Health

Dematerialization of Value

# Utopia?

- Technology Trends

- Nanotechnology      Clean ubiquitous Cheap Energy
- Synthesis      More Knowledge available to more people
- Computers      Assignment Project Exam Help  
                         Safer & Faster travel
- Robotics      <https://eduassistpro.github.io/> playing field

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zed anything

- What Should We Do?

Better Health

Dematerialization of Value

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# Killer Robots? Really?

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It's a L <https://eduassistpro.github.io/> located.

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# Today

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- Technology & Labor
- What is Money?  
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# Technology & Jobs

- Replace Workers

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# Technology & Jobs

- Replace Workers
- Eliminate Jobs

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# Technology & Jobs

- Replace Workers

- Eliminate Jobs

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- Enhance W

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# Technology & Jobs

- Replace Workers

- Eliminate Jobs

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- Enhance W

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- Create New Jobs

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# Some Questions

- Is this time different?
- Why no significant job loss?
- Why is rate of GDP growth decreasing?  
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- What is new  
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- If there is ?  
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# Some Questions

- Is this time different?
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# Technology Revolutions

- TR1: (aka First Industrial Revolution) 1760-1830
  - Coal powered steam engine
  - Cotton Gin
  - Steam-powered printing presses

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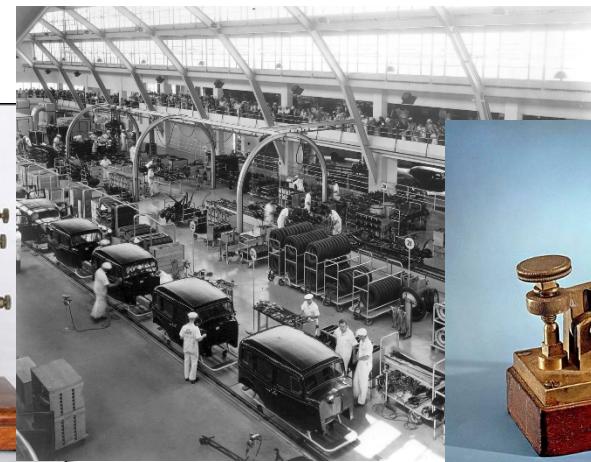
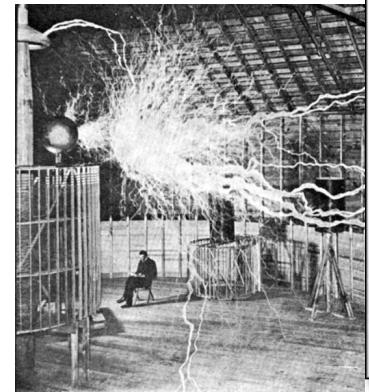
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1965-?

# Technology Revolutions

- TR1: (aka First Industrial Revolution) 1760-1830
  - Coal powered steam engine
  - Cotton Gin
  - Steam-powered printing presses
- TR2: (aka 1860-1910)
  - Electricity
  - Assembly Lines
  - Telegraph/Telephone



# Technology Revolutions

- TR1: (aka First Industrial Revolution) 1760-1830
  - Coal powered steam engine
  - Cotton Gin
  - Steam-powered printing presses
- TR2: (aka 1860-1910)
  - Electricity
  - Assembly Lines
  - Telegraph/Telephone
- Third Technology Revolution 1965-?
  - Renewables
  - Manufacturing without assembly
  - Computation

# Just Like TR1 and TR2

TR3 will:

- Improve productivity
- Increase coverage)
- Cause massive

# But, TR3 is different

- Continued exponential improvement  
(E.g., Computation, Networking, Renewable energy,  
Synthetic biology, ML&BD, Robotics, ...)

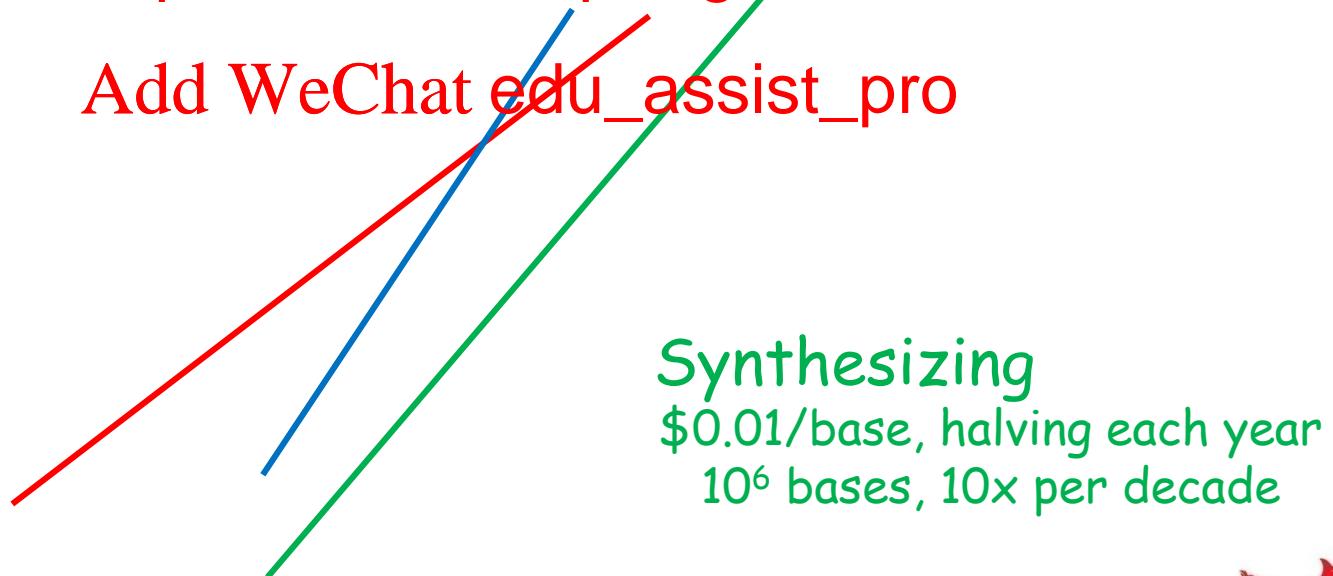
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"Moore's law"

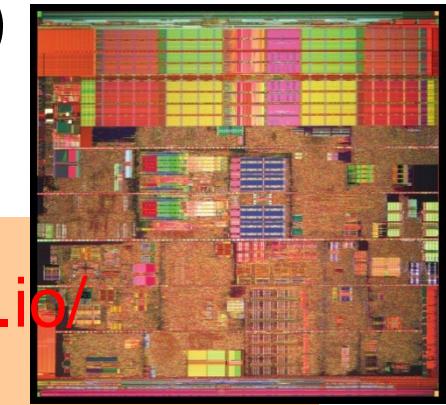
Sequencing



Synthesizing  
\$0.01/base, halving each year  
10<sup>6</sup> bases, 10x per decade

# But, TR3 is different

- Continued exponential improvement  
(E.g., Computation, Networking, Renewable energy,  
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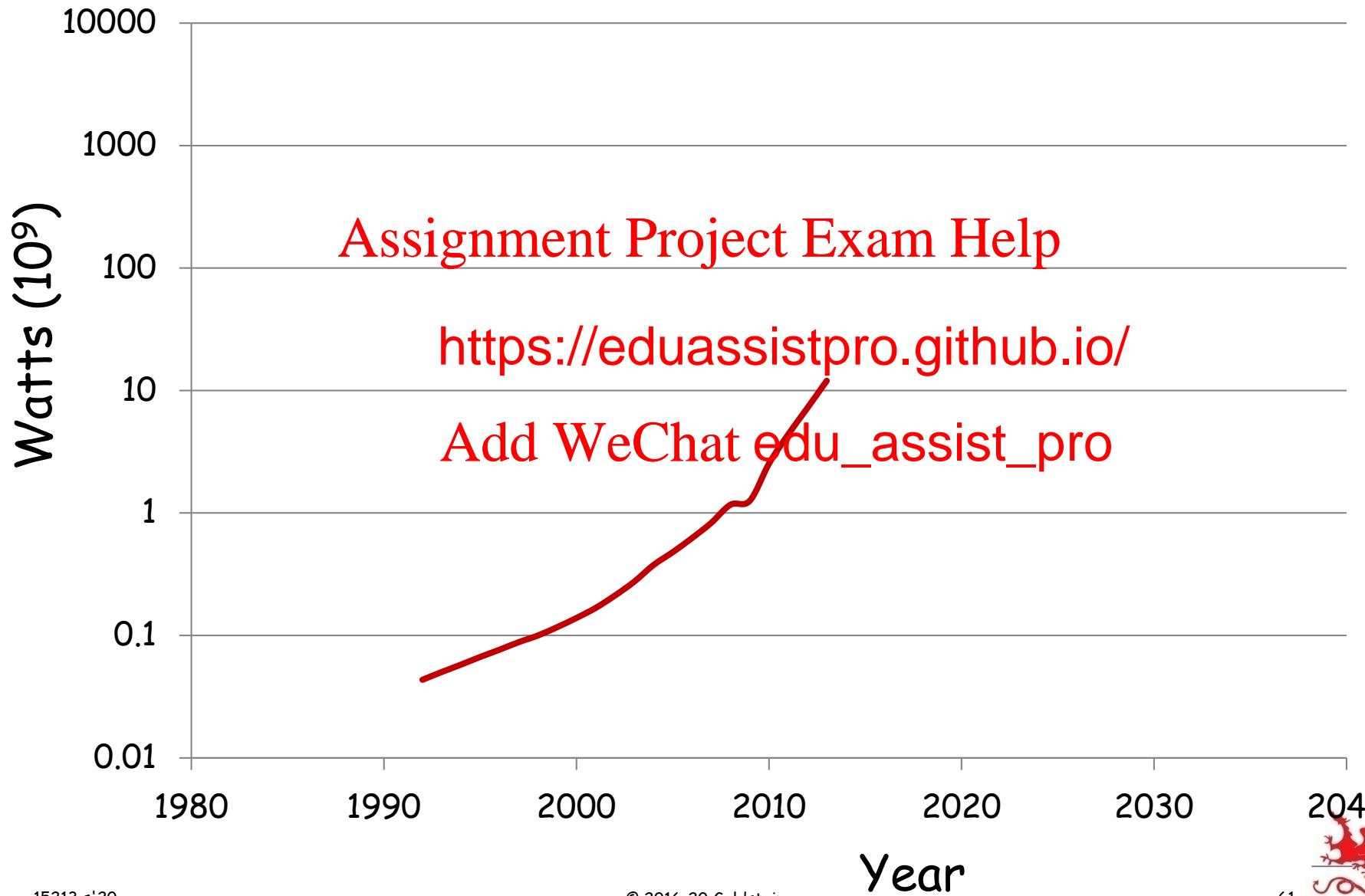
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Don't get  
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It is not just ab  
utation.

Assembly-Free Manufacturing!

# Solar Power in US

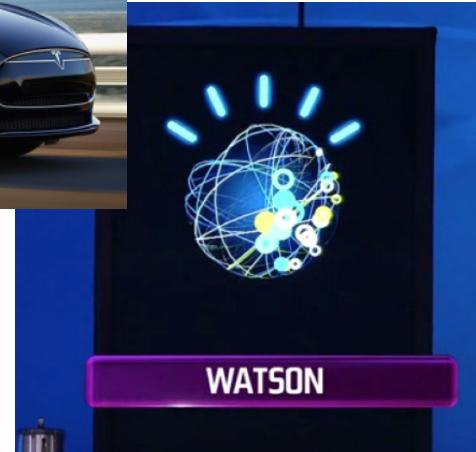


# But, TR3 is different

- Continued exponential improvement  
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- Technology is able to do "Uniquely human" c <https://eduassistpro.github.io/>



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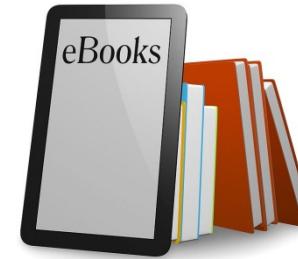


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- Labor component of original cost of production → 0!

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- Technology is able to do "Uniquely human" c <https://eduassistpro.github.io/>
- Labor component of marginal cost of production → 0!  
(E.g., how much labor to produce and deliver the next copy of an eBook?)



# But, TR3 is different

- Continued exponential improvement  
(E.g., Computation, Networking, Renewable energy, Synthetic biology, ML&BD, Robotics, ...)
- Technology is able to do "Uniquely human" c <https://eduassistpro.github.io/>
- Labor component of marginal cost of production → 0!  
(E.g., how much labor to produce and deliver the next copy of an eBook?)
- Unlike TR1 and TR2, TR3 will create massive technological unemployment

# Not Much Work Now for Horses

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TR2: Forever ended the horse as a factor of production.

# Not Much Work Now for Horses

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With respect to human labor:  
Is TR3 the last Technology Revolution?

# Wait a Second!

- Where are the exponential job losses?

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# Losses yes, Exponential no

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No real change in median income for 40 years!



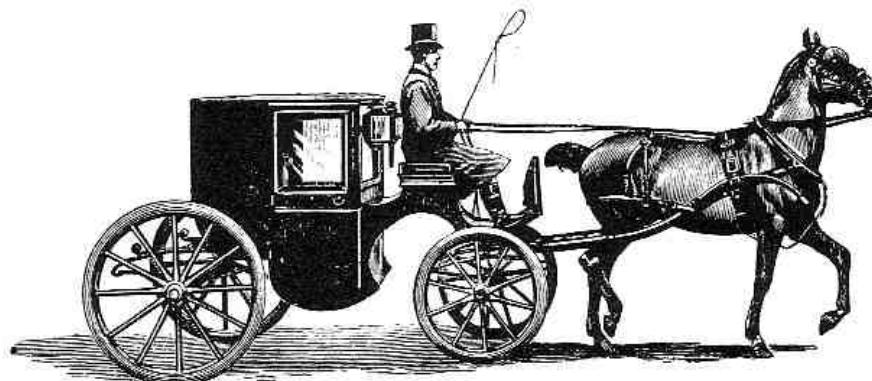
# Wait a Second!

- Where are the exponential job losses?
- What about new jobs?

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# What Are The New Jobs?

- Yes, there will be traditional jobs which require, e.g.,
  - Creativity
  - Empath
  - Entrepr [Assignment Project Exam Help](https://eduassistpro.github.io/)
  - Social Skil [Add WeChat edu\\_assist\\_pro](#)

Aside:  
Requires changing our  
educational goals and  
methods!

# What About New Jobs?

- Yes, there will be traditional jobs which require, e.g.,
  - Creativity
  - Empath
  - Entrepr <https://eduassistpro.github.io/>
  - Social Skil [Add WeChat edu\\_assist\\_pro](#)
- But, as technology improves it will continue to take away jobs

Department of Artificial Empathy?

# What About New Jobs?

- Yes, there will be traditional jobs which require, e.g.,
  - Creativity
  - Empath
  - Entrepr [Assignment Project Exam Help](https://eduassistpro.github.io/)
  - Social Skil [Add WeChat edu\\_assist\\_pro](#)
- But, as technology improves it will continue to take away jobs
- And, those that remain are low paying.

# Wait a Second. Hmm.

- Where are the exponential job losses?  
*Around the corner?*
- What ab  
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H <https://eduassistpro.github.io/main>  
in human do  
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- Rate of productivity increase has slowed  
*Not, really.*  
*Average doesn't tell the whole story.*

# Remember the Horses ...

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With respect to human labor:  
TR3 is the last Technology Revolution

# Plenty of Resources

- TR3 economy produces an abundance of goods and services
- Most people are unemployable  
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- Most jobs <https://eduassistpro.github.io/> destroyed
- Those that remain are Add WeChat edu\_assist\_pro
- (some are created for a limited time.)

# What Should You Do Today?

- Study for 213 final.

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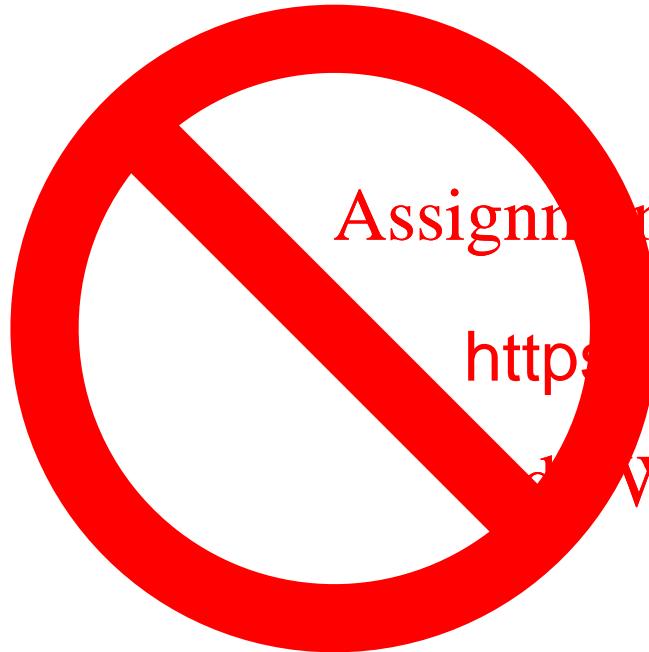
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# What Should You Do Today?

- More seriously:
  - Learn to learn
  - Be flexible
  - Expect **Assignment Project Exam Help**
- Its not o <https://eduassistpro.github.io/>
- In fact, soft skills **Add WeChat edu\_assist\_pro** as most important components of high-end jobs.

# What does this mean?



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# Horror or Opportunity?

- TR3 poses 2 existential questions for most everyone:

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- How to get <https://eduassistpro.github.io/> ded for life?

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- How to find meaning a y?

## We Need a Change in Perspective

# Plenty of Resources

- TR3 economy produces an abundance of goods and services
- Most people are unemployable  
*Assignment Project Exam Help  
(Technology)*
- What do th <https://eduassistpro.github.io/>



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# What will we do?

- Activities which require either:
  - Super-Creativity
  - Empathy on the part of the consumer
- Play

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How Will ~~We~~ Do it?

# Today

- Beyond Moore's Law
- Technology & Labor
- What is Money?  
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- 213 Final  
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# A new look at Money

- What makes money work:
  - A metric of value
  - A method of accounting
  - Trust the <https://eduassistpro.github.io/>

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# Today's Money

- What makes money work:
  - A metric of value
  - A method of accounting
  - Trust the <https://eduassistpro.github.io/>
- So today's currency
  - A static token
  - Backed by the state



# Today's Money

- What makes money work:
  - A metric of value
  - A method of accounting
  - Trust the <https://eduassistpro.github.io/>
- So today's currency
  - A static token
  - Backed by the state

But remember, it has no intrinsic value!



# TR3 & Money

- Currency doesn't need to be static token.
- Nor backed only by the state.

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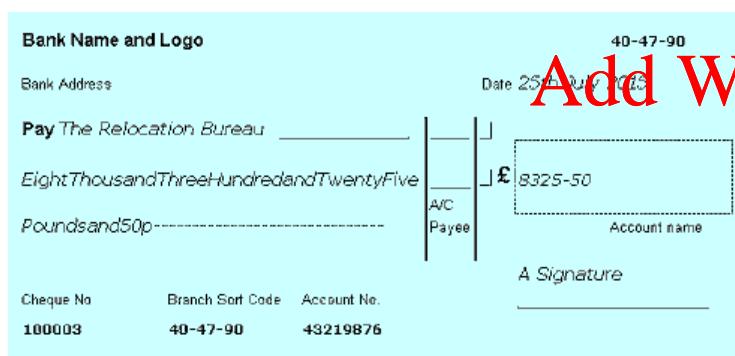
- Can we ~~h~~ ~~computat~~ ~~Add WeChat~~ with <https://eduassistpro.github.io/> to create a new form of money
- Goal: Monitize IOUs  
(I.e., Micro-bearer bonds)

# Before TR3

- Irish Banking Crisis ('60, '70, '76)
  - Banks closed
  - Checks can't clear
  - People u

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→ Good? →



Reputation Authority

# Before TR3

- Irish Banking Crisis ('60, '70, '76)
  - Banks closed
  - Checks can't clear
  - People u
- Assignment Project Exam Help
  - Banknotes

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# Before TR3

- Irish Banking Crisis ('60, '70, '76)
  - Banks closed
  - Checks can't clear
  - People u  
<https://eduassistpro.github.io/>
- Banknotes Add WeChat edu\_assist\_pro
- Credit networks for resource allocation

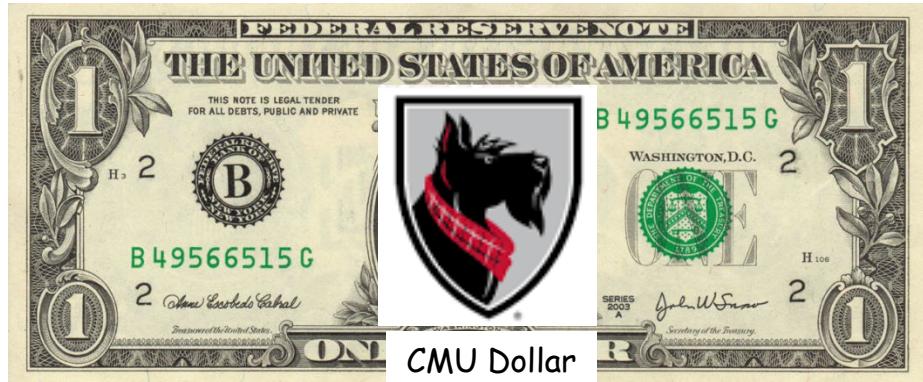
# TR3 & Money

- Currency doesn't need to be static token.
- Nor backed only by the state.

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<https://eduassistpro.github.io/>

- Imagine + Add WeChat edu\_assist\_pro own money backed issue their reputation.



# Who accepts Seth-Dollars?

- Certainly, I must.
- Anyone who expects to trade with me.
- People in my communities
- Most anyone Assignment Project Exam Help trade with someone I <https://eduassistpro.github.io/>
- The further Add the WeChat edu\_assist\_pro less likely.
- Everyone will decide their risk ↑



# Who accepts Seth-Dollars?

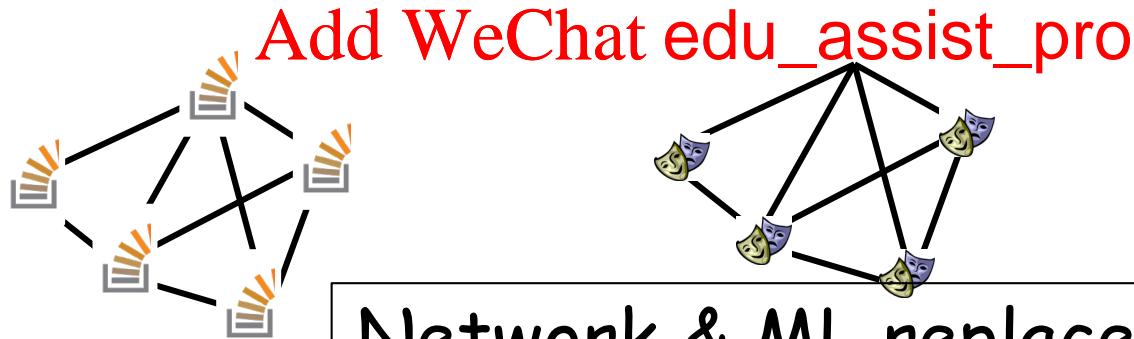
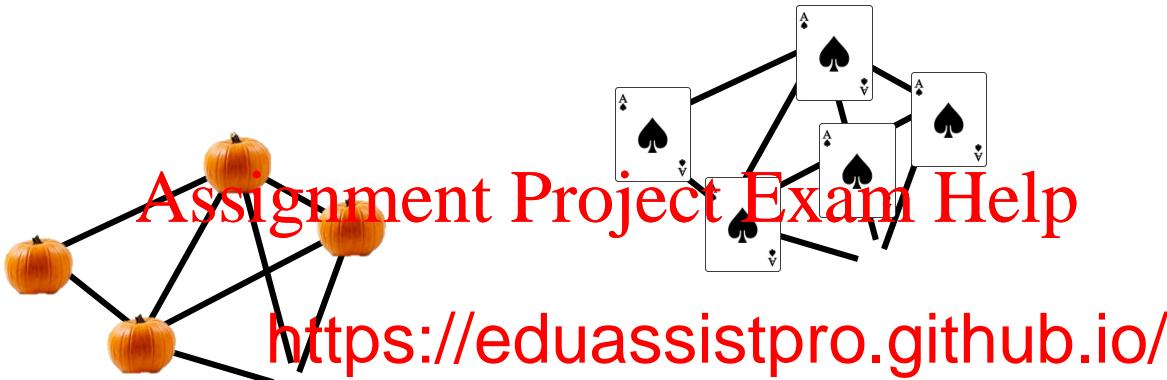
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- Most anyone ~~Assignment Project Exam Help~~ trade with someone I <https://eduassistpro.github.io/>
- The further ~~Add WeChat edu\_assist\_pro~~ less likely.
- Everyone will decide their risk tolerance.



Currency is “executable” and can have means to reduce risk.



# We Are All Members of Multiple Communities



# Money Requirements



- Transactions must be:
  - Secure
  - Fast
  - Low cost
  - Concurrent
- Currency itself
  - Forgery proof
  - Maintain value
- Controllable by Central Bank

# Money Requirements



- Transactions must be:
  - Secure ✓
  - Fast ✓
  - Low cost ✓
  - Concurrent https://eduassistpro.github.io/tem) ✓
- Currency itself ✓
- Controllable by Central Bank ✓

# Money Requirements



- Transactions must be:
  - Secure ✓ ✓
  - Fast ✓ ✗
  - Low cost Assignment Project Exam Help ✓ ✗
  - Concurrent https://eduassistpro.github.io/item) ✓ ✗
- Currency itself AddWeCan't edu\_assist\_pro
  - Forgery proof ✗ ✓
  - Maintain value ✓ ✓
- Controllable by Central Bank ✓ ✗

# Blockchain

- Used to track transactions
- Distributed
- Simple rule to resolve data races mai longest c -  
<https://eduassistpro.github.io/>
- Implications:
  - Need to wait to see if transaction went through
  - Need to have copy of all blocks everywhere

# Block chain

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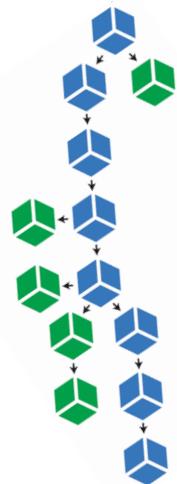
<https://eduassistpro.github.io/>

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- Worldwide network of the blockchain - a public ledger
- Longest chain is the official ledger
- For safety transactions must be broadcast everywhere

# Blockgraph: Principle of Locality

Pittsburgh



New York

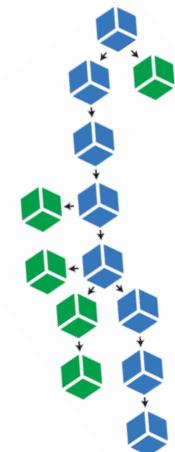
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Tokyo

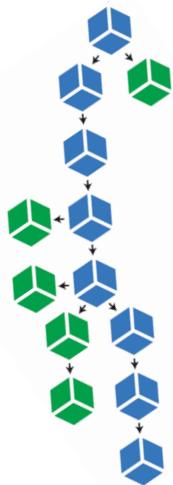
Paris



Most transactions are local, so they stay local

# Tied together with a global chain

Pittsburgh



Global

New York

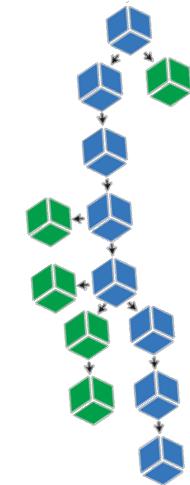
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Tokyo

Paris



# Money Requirements



- Transactions must be:
  - Secure ✓ ✓
  - Fast ✓ ✓
  - Low cost ✓ ✓
  - Concurren Assignment Project Exam Help (tem) ✓ ✓
  - Currency Add WeChat edu\_assist\_pro ✓
  - Forgery proof ✗ ✓
  - Maintain value ✓ ✓
- Controllable by Central Bank ✓ ✗

# Shameless plug

- Interest Assignment Project Exam Help his for the summer? <https://eduassistpro.github.io/>
- If so, Send me an e Add WeChat edu\_assist\_pro

# Impacts of TR3

- Without Planning:

- Massive disruption
- Increased wealth inequity
- Bad stuff



Seth Dollar

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- With Plan <https://eduassistpro.github.io/>

- An amazing future
- Best chance for success is a bottom-up, distributed system that uses the market  
→ Reinvent Money based on Reputation

# Shameless Plug - part 2

- How to revive economy in time of pandemic?
- Businesses and People need loans to get by til Assignment Project Exam Help ens
- Monitize [https://eduassistpro.github.io/  
OUs!](https://eduassistpro.github.io/OUs!)  
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# Shameless Plug - part 2

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Seth Dollar

- Interested? send me an email!

# TAs for Fall 2020

- The instructors for 15/18-213/513/613  
need you  
please apply if you did well in 213 and want to be a TA

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~~https://eduassistpro.github.io/~~ You?

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<https://www.ugrad.cs.cmu.edu/ta/F20/>

# Final Exams and Grade

- Please study well  
imitate machine learning
- Attend the Final Review  
May 3, 6PM EDT Zoom (see Piazza for link)  
**Assignment Project Exam Help**
- Remember <https://eduassistpro.gitub.io/>  
<http://www.cs.cmu.edu/~213/exams>  
Add WeChat `edu_assist_pro`
- Grading algorithm: (almost) no curving  
exam/lab/quiz/PS distribution:  
<http://www.cs.cmu.edu/~213/syllabus/syllabus.pdf>  
weight of labs: <http://www.cs.cmu.edu/~213/assignments.html>
- Double-check your scores  
get in touch with us if anything looks wrong in autolab

The screenshot shows a Microsoft Internet Explorer window displaying a final exam template. At the top, there are fields for "Andrew ID (print clearly!)" and "Full Name". Below that, it says "15-213/18-213, Fall 2012" and "Final Exam" with the date "Monday, December 10, 2012". The "Instructions" section contains several bullet points: "Make sure that your exam is not missing any sheets, then write your Andrew ID and full name on the front.", "This exam is closed book, closed notes (except for 2 double-sided note sheets). You may not use any electronic devices.", "Write your answers in the space provided below the problem. If you make a mess, clearly indicate your final answer.", "The exam has a maximum score of 98 points.", and "The problems are of varying difficulty. The point value of each problem is indicated. Good luck!". Below the instructions is a table for point distribution:

1 (18)
2 (06)
3 (06)
4 (08)
5 (10)
6 (12)
7 (06)
8 (10)
9 (12)
10 (10)
<b>TOTAL (98)</b>

At the bottom right, it says "Page 1 of 20".

# Course Evaluation

- Please fill out the course evaluation you should have and will receive email about it
- Please provide constructive comments this is your chance to make 213 better  
**Assignment Project Exam Help**
- Please be fair with the university and [https://eduassistpro.github.io/numbers](https://eduassistpro.github.io/)
- TA evaluation  
<https://www.ugrad.cs.cmu.edu/~ckpro>  
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