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The Butterfly Effect: The nature of chaos and how it shapes our world

November 16, 2017

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The Chaos of Everyday Life

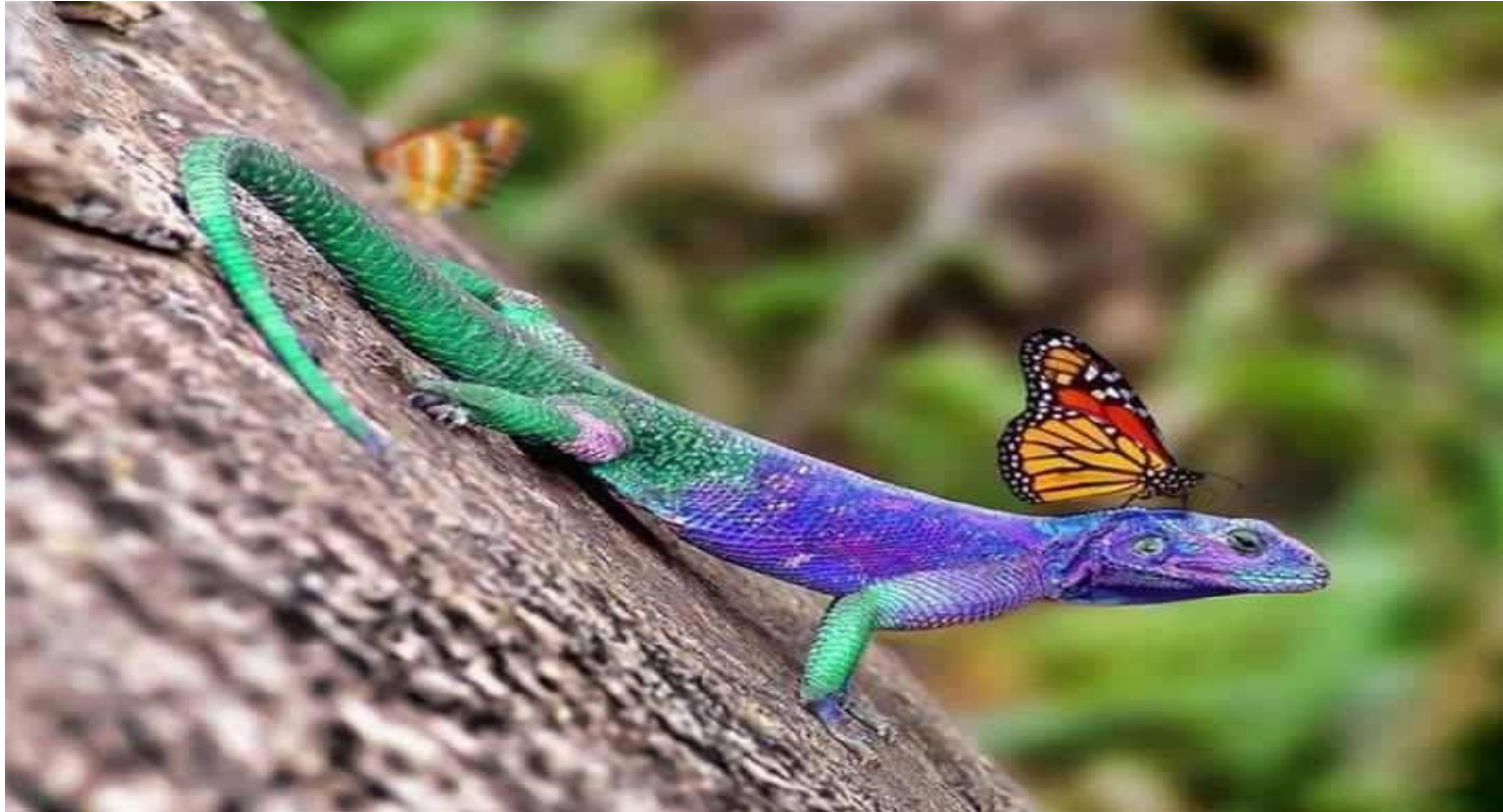
Implications of Chaotic Systems

- The outcomes of dynamic systems, that contain complex and chaotic information, are usually not predictable as the relationship between all the factors that play a role in determining the outcome cannot be fully explained or described by any model.
- Insight as to why some outcomes of an event appear to be completely unexpected. The variables and relationship between all the variables in the system would have to be known before accurate predictions could be made.



“Chaos is when the present determines the future, but the approximate present does not approximately determine the future” — Edward Lorenz

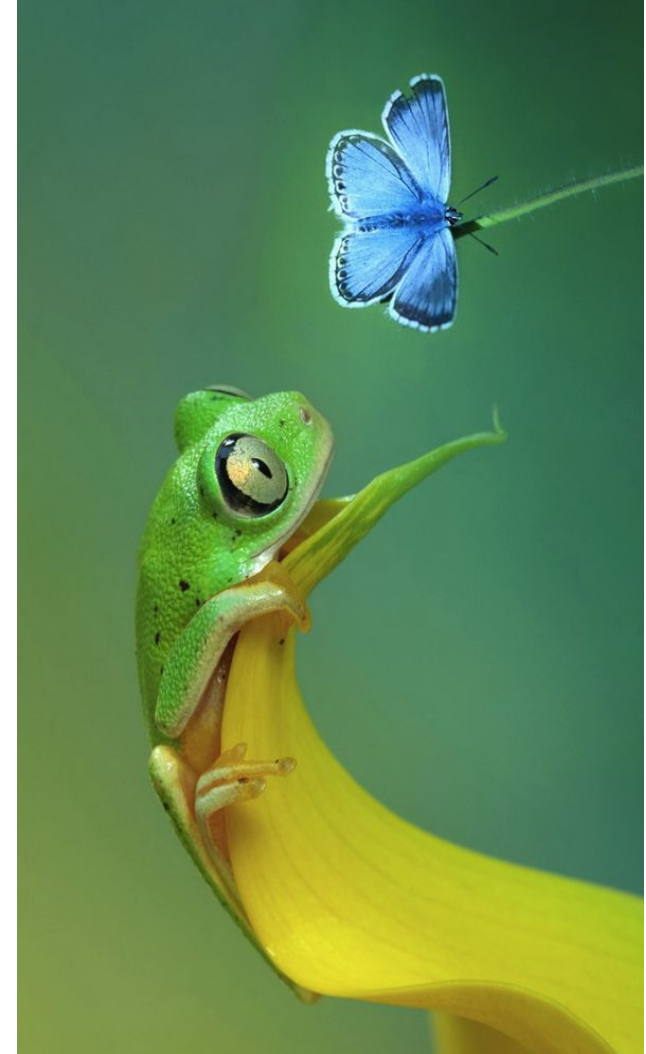
The Butterfly Effect



The Butterfly Effect

“A butterfly flaps its wings in Brazil and these small disturbances in the air, the wind speed and the air pressure cause a tornado in Texas”

The butterfly effect is a concept that comes from chaos theory, a branch of mathematics used to describe chaotic systems, and is used to describe sensitivity of chaotic systems to initial conditions.



Illustrating Sensitivity to Initial Conditions

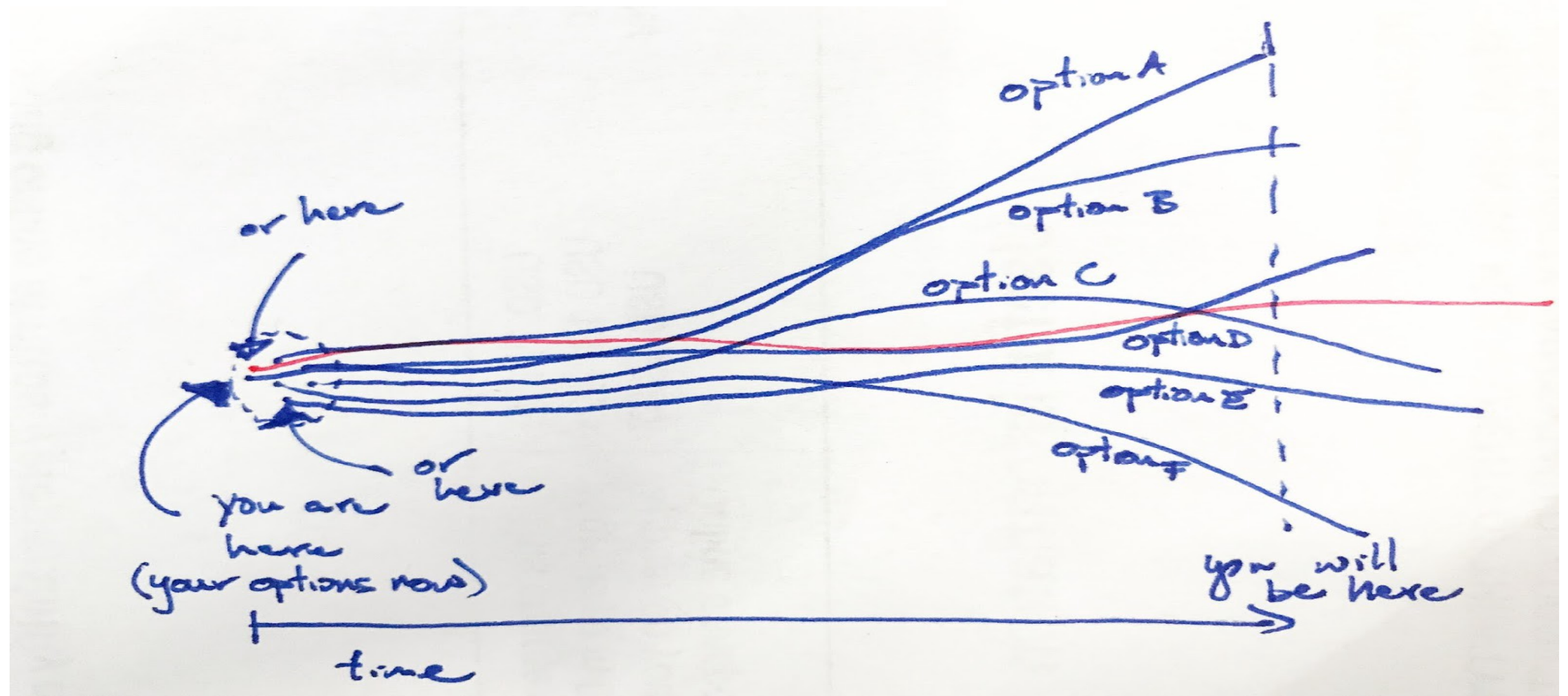
Compound interest is a system which is sensitive to the initial conditions.



	Investment A	Investment B
Present Value	R 5 000.00	R 5 000.00
Interest Rate	6%	7%
Period	10 Years	10 Years
Value After 10 Years	R 8 954.24	R 9 835.76
Difference in Return		R 881.52
Percentage Difference		18%



The Butterfly Effect in the Real World



The Reality of the Butterfly Effect

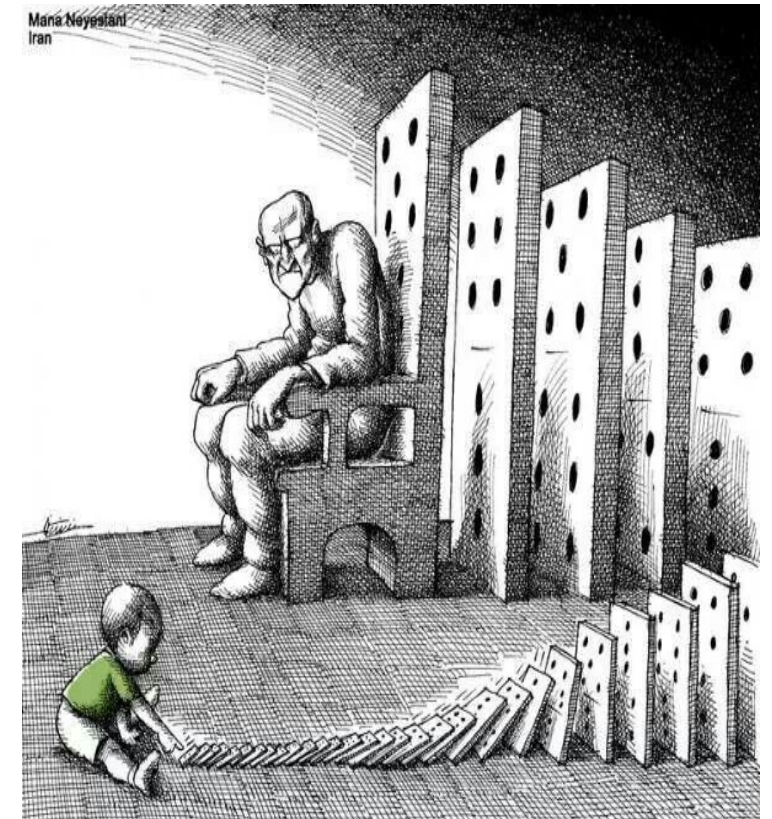
We know that:

- Chaotic systems are sensitive to initial conditions. Small changes can be magnified and unexpected outcomes are totally possible in highly complex systems.
- Life is a complex chaotic system with many variables that are highly dependent on each other and constantly changing over time which means that the outcomes based on different initial conditions can be almost impossible to forecast.
- **However:**
- The butterfly effect is overstated and slightly misunderstood by the general public.



Misconceptions Around the Butterfly Effect

- The butterfly effect seems to imply that the small effects within a chaotic system will lead to massive unexpected outcomes such as a tornado created from a butterfly's flapping wings. However the reality is much more subtle and the processes we normally work on are not as sensitive to initial conditions as for example weather forecasting models.
- It also seems to imply small effects alter the outcomes which is true but misses the point. The butterfly effect really highlights the importance of initial factors and the unexpected nature of the outcomes related to these factors rather than size of these factors
- The butterfly effect is also confused with another concept, the domino effect which describes the chain reaction of events that have a singular cause.
- The domino effect has a much narrower scope and the outcome is able to be traced back to the source where as the butterfly effect has very wide scope and the outcome does not always appear to be related to the source. These two concepts are closely related however and is often difficult to distinguish from each other.

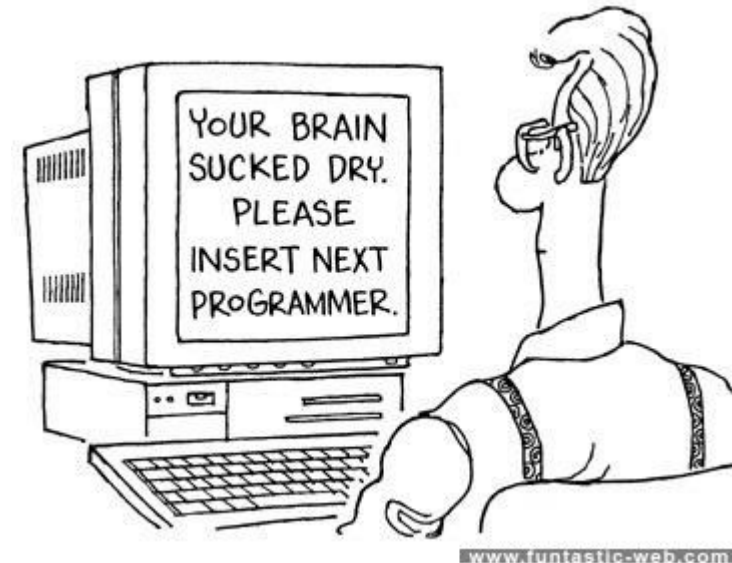


The Pharmaceutical Industry and the Butterfly Effect



The Landscape of the Pharmaceutical Programming Industry

- The pharmaceutical industry is highly regulated with many processes and SOPs that provide guidance as to how a particular task should be done and what the expected outcome should be.
- Technology provides us with powerful programming languages and macros that automate certain processes, tools that improve efficiencies and applications that make communicating with people much easier.
- Time is especially scarce within this industry. Datasets and outputs need to be created in set timeframes which often do not leave any room for error.



How do Our Programming Inventions Accommodate Chaos?

Why do We Invent Programming Tools

- Tools, macros and applications are introduced to streamline processes that are:
 - Repetitive
 - Take long to complete
 - Maintain compliance with customer or regulatory standards
 - Or to further increase the efficiency of a larger system.



How do Our Programming Inventions Accommodate Chaos?

Why should we keep the butterfly effect in mind when creating tools?

- The aim when creating these tools should be creating tools that are repeatedly able to produce expected results. If a tool is not able to do this, then it serves little purpose.
- The way to avoid to creating tools that produce unexpected results is to simply limit the number of variables that are needed for that tool to work. Limiting the number of variables means there are less unknown factors at the initial stages that could magnify and influence the result.
- The other way of avoiding unexpected results is to validate the tool for all types of inputs. However it can become increasingly difficult over time to maintain such a tool as it constantly needs to be updated to handle different datatypes, formats or document types. This also tends to start creating a secondary butterfly effect loop within the tool.

Software can be chaotic, but we make it work



Expert

Trying Stuff
Until it Works

O RLY?

*The Practical Developer
@ThePracticalDev*

But Are We Safe?

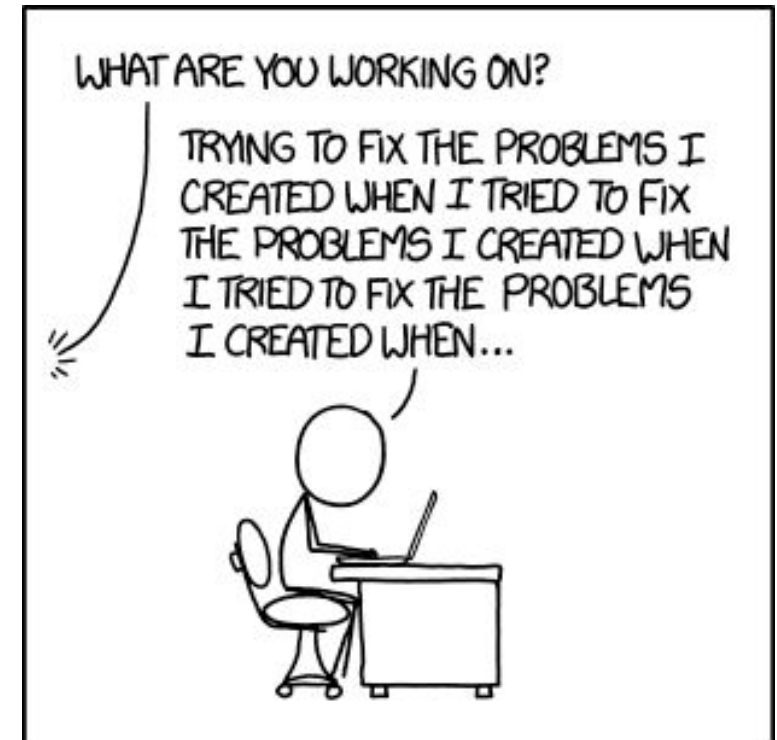


Some examples of the butterfly effect causing issues within programming

Problem Solving Approaches

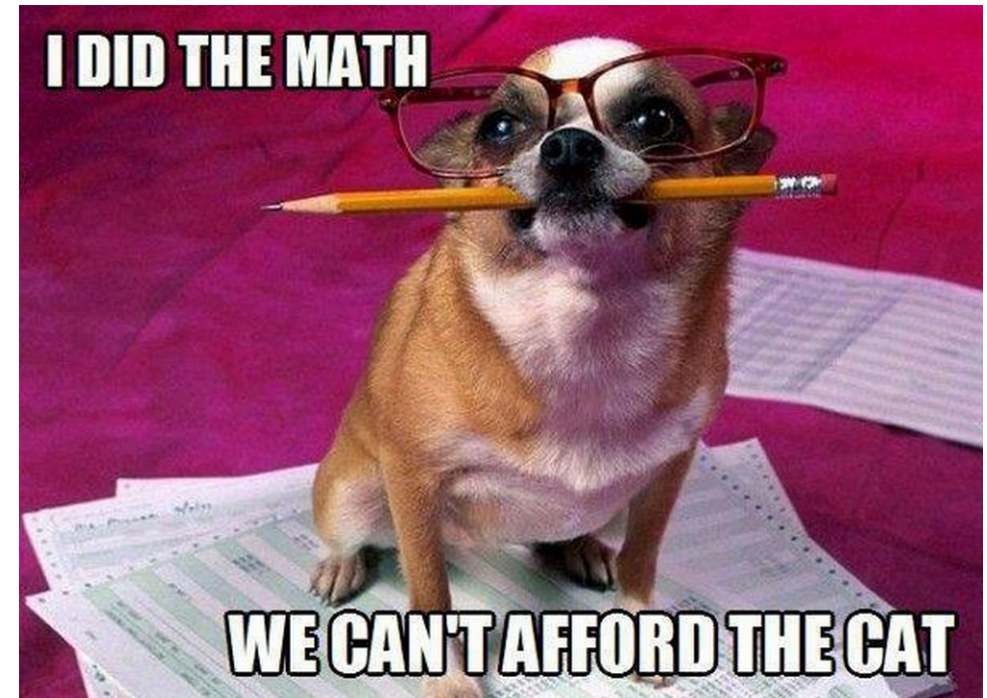
The nature of the butterfly effect can provide us valuable insights into effective ways of problem solving.

- Good things take time to create and are often the result of small actions that build on each other.
- The details of any task are extremely important.
- Viewing the problem through different points of view.
- Limiting unknown factors through better communication.
- Standard operating procedures and processes.
- Hindsight is always 20/20 vision – Learning from mistakes



Conclusion and Closing Comments

- The butterfly effect is a seemingly innocuous concept that can make for a very interesting discussion.
- The outcome is almost always difficult to explain.
- Often the small overlooked details can cause the most unexpected results.[snowball effect].
- Arriving at a desired outcome while navigating chaotic circumstances can be a challenge. Using technology to keep chaos at bay along the way help us arrive safely at our required destination.
- Fine-tuning efficiencies through continuous improvement allow us to control circumstances over and over again, without expending much more energy.



Questions?

1) How can we ensure that chaotic inputs do not cause chaotic outputs?

2) How can we use the butterfly effect to our advantage?