BANDWITH PORTFOLIO RISK MANAGEMENT

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Introduction and Context

- Telecommunications / long-distance operator
- Pre-defined need for Bandwidth
- Ressources needed (purchasing / lease from a third party operator)
  - Different possible strategies

- Two types of risks taken into account:
  - Market Risk
    - Uncertainties on future returns resulting from changing market conditions
    - Made of both a price effect and a quantity effect
    - On a commodity market (physical substance, such as food, grains, and metals, which is interchangeable with another product of the same type / more generally, a product which trades on a commodity exchange; this would also include foreign currencies and financial instruments and indexes):
      - predominance of the price effect
    - Illustration: contract with a duration longer than necessary
      - Pros: to benefit from reduced monthly rates
      - Risk: surplus sold off on the spot market at an unknown price
  - Provider risk
    - Appears when the provider fails to honour his agreements
    - Is evaluated through the loss suffered when a replacement solution is to be set up
    - Illustration: uncertainties on the provider capacity/incapacity to deliver the service
      - Unknown time of failure
      - Repurchase of bandwidth for replacement at an unknown price on the spot market

Definition of a need in Bandwidth

- Definition of a need in bandwidth
  - Known demand:
    - Between a given couple of *Origine-Destination* PoPs
    - for *a given quantity*
    - From a specified date
    - For a given period of time
    - With a given quality-of-service
  - Remarks:
    - The Need is supposed to be deterministic
    - The need is supposed to be unique (only one O-D couple)

- Example
  - Known demand:
    - Between London and Brussels
    - for *4 x 155Mbps*
    - From the 1st of Jan *2005*
    - during *11 months*
    - With a *Qos of 99%*

Products available on the market

- Bandwidth market
  - forward/future contracts
    - Forward: OTC, a cash market transaction in which a seller agrees to deliver a specific cash commodity to a buyer at some point in the future, privately negotiated
    - Future: standardized, occurs through a clearing firm
  - Spot market contracts (a market in which commodities, such as grain/gold/crude oil are bought and sold for cash and delivered immediately)
    - Contracts: any couple of cities / 155Mbps / 1 month
- Hiring strategy
  - The operator must satisfy a bandwidth demand for a given duration
    - Long positions taken in forward contracts, the positions being longer than necessary to answer to the initial need
    - Bandwidth on the period of time remaining after the need has been answered is sold out on the spot market
  - Risks modelling
    - Future spot prices are modelled by random variables (market risk)
    - Operator's failures and the financial compensation for them are modelled by random variables (provider risk)

Problem Modelling

- Physical graph vs multi-graph of contracts

- Combinatorial problem
  - 2 types of contracts/market ⇒ 24 contract-paths
  - 4 types de contracts/market ⇒ 160 contract-paths

- Investment solution and path of contracts

  - For each path of physical network links between an origin and a destination point for the demand their can be one (or more than one) path of contracts that the operator can buy to satisfy his/her need

  - The purchase of a path of contracts is an investment decision which is more or less risky
    - Uncertain evolution of the spot market for links making up a path until the bandwidth is to be resold
    - Risk of failure/deficiency in the service offered by the provider together with its financial consequences

Financial Concepts

Notions of Asset and Portfolio

- Asset:
  - ✓ Any item of economic value owned by an individual or corporation, especially that which could be converted to cash
  - ✓ Action, option, material property, etc.

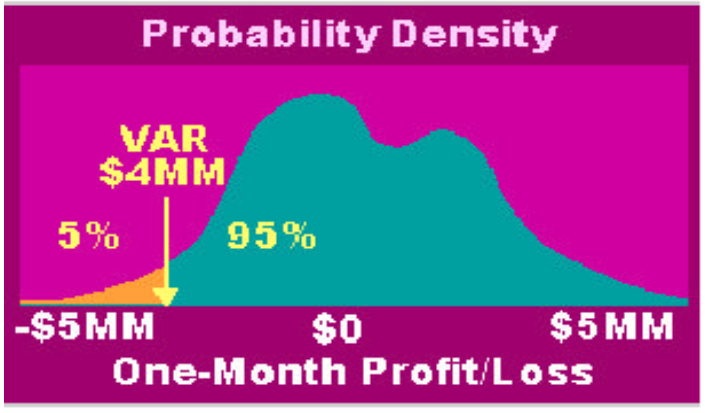
- Financial portfolio:
  - ✓ A collection of financial assets all owned by the same individual or organization
  - ✓ Interest = diversification or even hedging
    - Diversification : a portfolio strategy designed to reduce exposure to risk by combining a variety of investments, which are unlikely to all move in the same direction. The goal of diversification is to reduce the risk in a portfolio.

      (convexity of the variance function)
    - Hedging : an investment is made in order to reduce the risk of adverse price movements in a security, by taking an offsetting position in a related security

Value-at-Risk

- Principle:
  - ✓ To give a unique number characterizing a position (portfolio) by also taking into account the risk factors

- Definition:
  - ✓ Measure of the potential maximal loss in value of a portfolio of (financial) instruments with a given probability α and time horizon *t*



Concepts transposed to telecoms

Notions of Asset and Portfolio

- Telecom asset here considered:
  - ✓ Any path of bandwidth contracts answering to the initial need
- Portfolio of paths
  - ✓ Set of contract path owned by a long-distance operator

Value-at-Risk

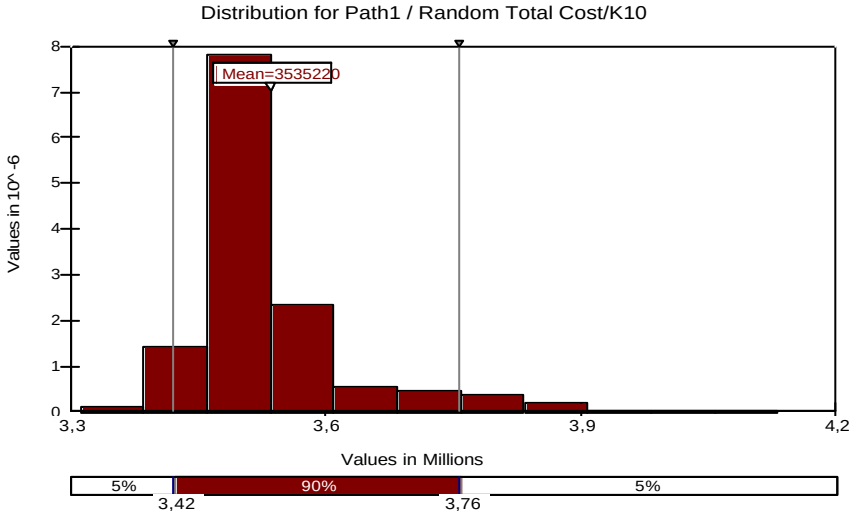
- Principle:
  - ✓ To give a unique number characterizing a portfolio of paths of bandwidth contracts by also taking into account 2 risk factors, namely
    - *Market risk*
    - *Provider risk*
- Definition:
  - ✓ Measure of the minimal return of a portfolio of paths of bandwidth contracts answering to a given need, with a given probability α and on the time horizon of the need

Investment Decision and Risk Management (1)

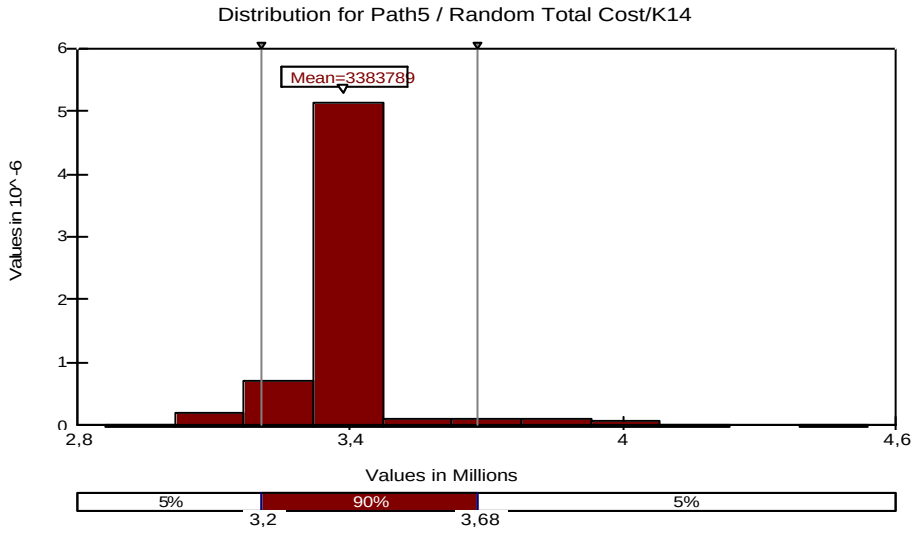
- Investment decision in a « mono-asset » approach
  - How to choose the « best possible path of contracts » ?
    - A path of contracts = a random variable represented by its probability density function
    - Question : is it better to invest in a path of contracts which will :
      - Give the highest profit
      - Give the less risky profit (minimal variance…)
      - Give the highest minimal profit with a 80/90/95% confidence interval (Value-at-Risk concept)
    - Answer : the adopted choice criterion reflects the investor's degree of aversion to risk

Which is best between those two investment solutions (illustrated by their respective probability density functions) ?

Representation of two investment solutions by their probability density function : which is the best ?



vs



Investment Decision and Risk Management(2)

- Investment Decision in a « multi-asset » approach: management of a portfolio of paths
  - In which subset of contract-paths (rather than single contract-path) are we to invest in order to drop the level of risk ?
  - Risk management methodology
    - Choice of a risk criterion : Value-at-Risk with a 95% confidence interval
    - Decision-making issue : how to find a convex combination of potential paths of contracts optimizing the risk criterion ?

⇒Stochastic optimization problem

⇒Heuristic solving method : Markowitz method

Process in progress… (1)

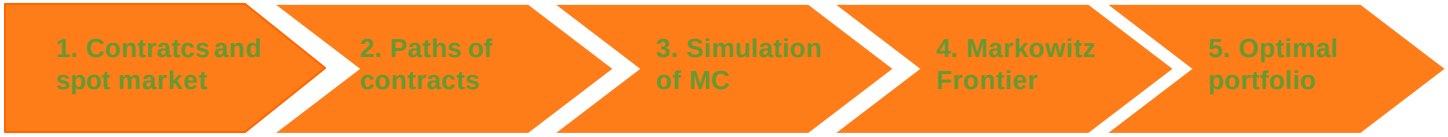
- Aim: to make a portfolio of bandwidth contracts allowing
  - to answer to our need… in an optimal way considering the criterion of Value-at-Risk on the total cost

- The 3 Cost components taken into consideration for each path of contracts are
  - 1 deterministic component: buying cost specified by the contracts
  - 2 stochastic components:
    - Surplus valuation for the contracts corresponding to positions longer than strictly necessary
    - Backup cost in case of a failure of the provider

Process in progress… (2)

➔ Steps

1. Analyse of the need and all possible means to answer it
   - ✓ Characteristics of all the available forward contracts to be gathered
     ⇒ modeling of the stochastic variables linked to the failure of a provider
   - ✓ Spot prices history for all couples of involved O-D to be gathered / Forecasts to be made
     ⇒ modeling of the stochastic variables representing the spot prices in the future
2. Combination of available forward contracts to create all possible paths answering to the need
3. Estimation of the probability distributions of the costs associated with each path thanks to a Monte Carlo simulation
   - ✓ Drawing of values for future spot prices stochastic variables (price of resale of the surplus bandwidth / purchase price in case of failure/deficiency)
   - ✓ Drawing of values for provider failure stochastic variables
4. Determination of the efficient portfolios (portfolios contract-paths minimizing the risk for a given level of cost = Markowitz frontier)
5. Selection, amongst the efficient portfolios, of the one optimizing the chosen criterion (95% VaR)



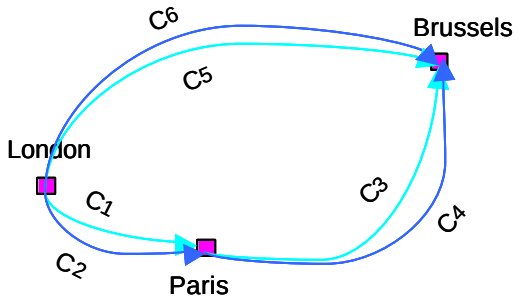
In brief on an example / Step 1

1. Contracts and spot market

1. Analyse of the need and all possible means to answer it

- Need: Known demand
  - Between London and Brussels
  - for *4 x 155Mbps*
  - From the 1st of Jan *2005*
  - during *11 months*
  - With a *Qos of 99%*

- Available contracts and spot markets associated with them
  - 2 types of contracts/market



date\Link	Spot(London-Paris;1month;€)	Spot(Paris-Brussels;1month;€)	Spot(Londres-Brussels;1month;€)
j-04	523412	650446	1275892
f-04	388255	413899	809716
m-04	343072	368278	718308
a-04	297890	322658	626902
m-04	254028	275883	532868
j-04	236527	268621	519076
j-04	212981	244618	466830
a-04	209232	219878	417264
s-04	189142	195286	376174
o-04	169052	170694	335086
n-04	165057	163086	313172
d-04	163443	162100	310782
j-05	150806	146815	280694
f-05	149938	145707	280406
m-05	149070	144599	280116
a-05	144304	139200	270582
m-05	108242	91894	179088
j-05	99617	91652	178218
j-05	98503	89617	170950
a-05	96349	86479	163930
s-05	94196	83341	156910
o-05	92212	82767	154622
n-05	83801	62162	153964
d-05	75390	61408	153308
j-06	75123	55799	153334

In brief on an example / Step 2

2. Paths of contracts

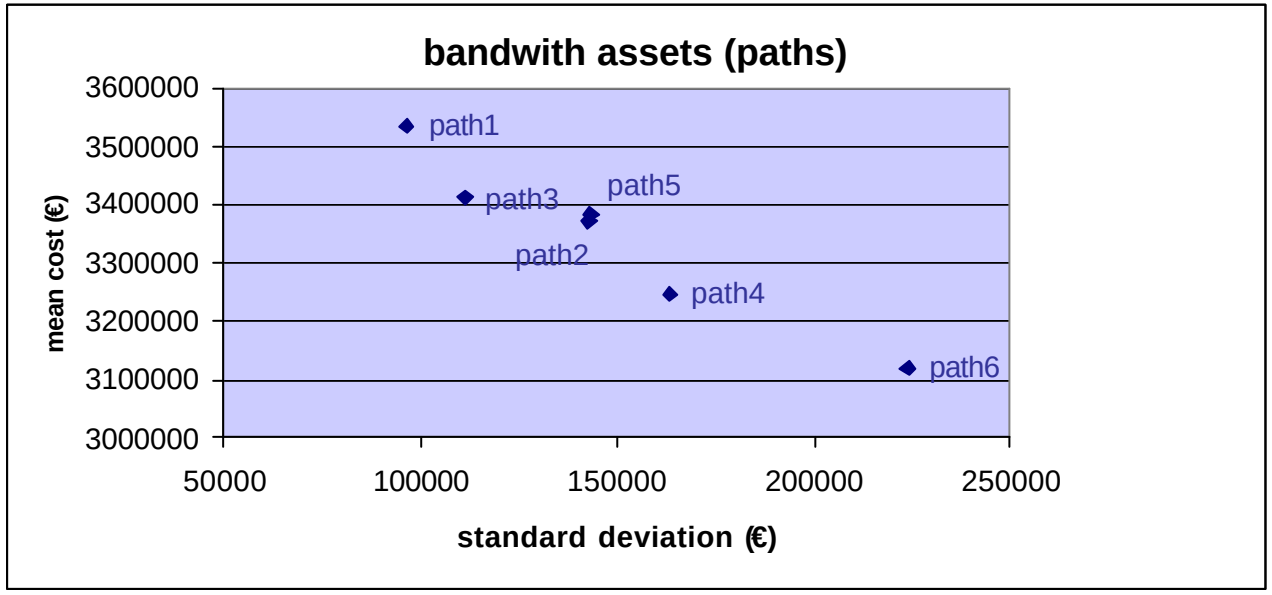
➔ Combination of available forward contracts to create all possible paths answering to the need

- Path1={C1, C3}, Path2={C2, C3}, Path3={C1, C4}, Path4={C2, C4}, Path5={C5}, Path6={C6}

In brief on an example / Step 3

3. MC simulation

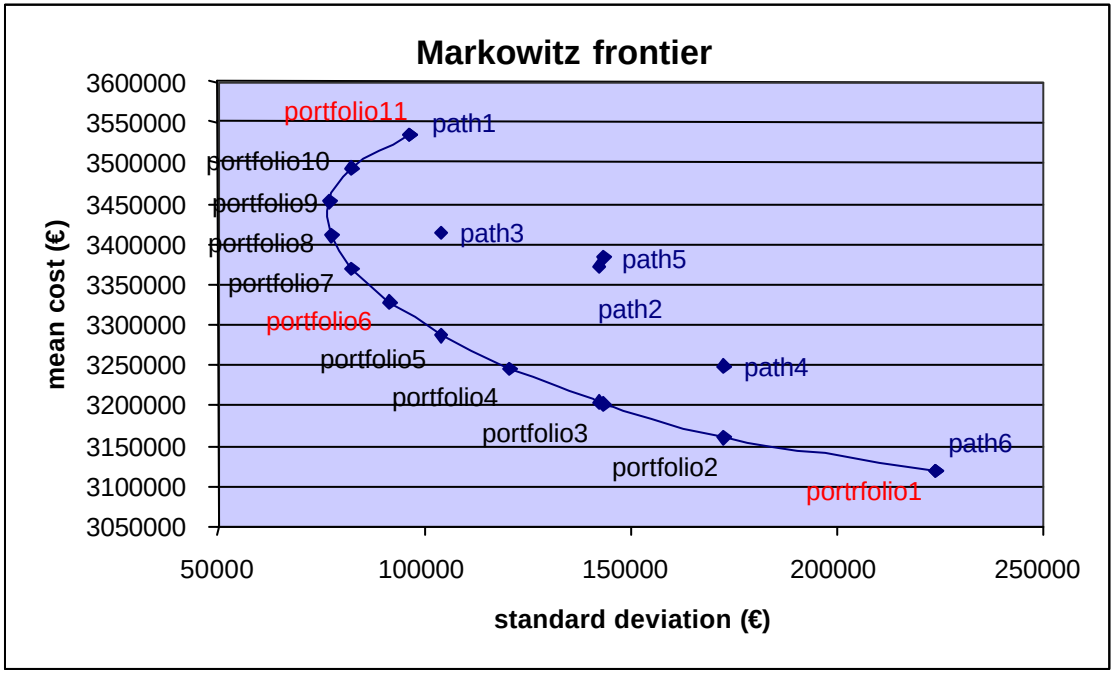
➔ Estimation of the probability distributions of the costs associated with each path thanks to a Monte Carlo simulation

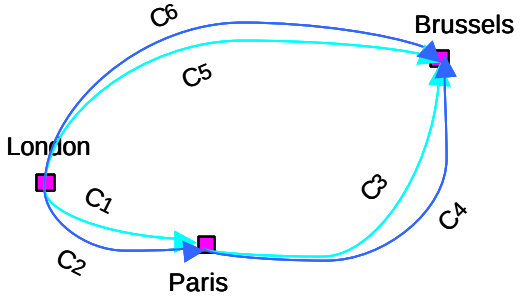


In brief on an example / Step 4

4. Markowitz frontier

➔ Determination of the efficient portfolios

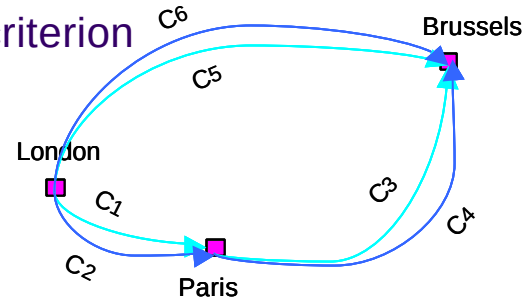


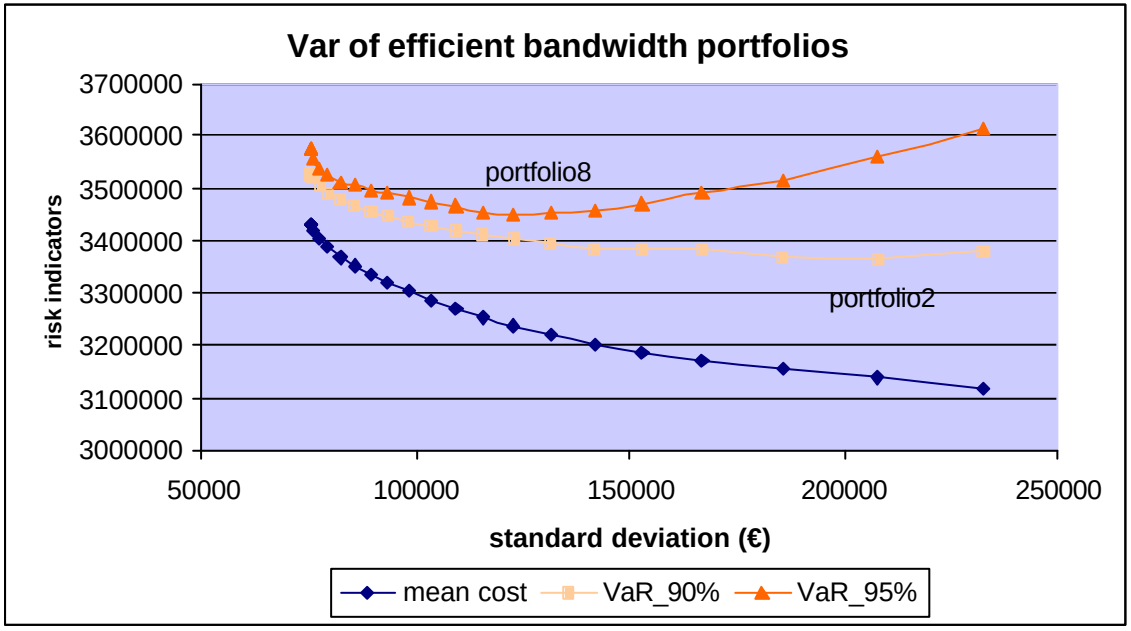


In brief on an example / Step 5

5. Optimal portfolio

➔ Selection of the best efficient portfolio, in accordance with the VaR criterion





	Portfolio 2	Portfolio 8
Path 1	0%	0%
Path 2	0%	0%
Path 3	0%	0%
Path 4	13%	40%
Path 5	0%	25%
Path 6	87%	35%

Conclusion

- Approach to be tested on real data
- Other domains in which the approach could be put into practice
  - Management of a portfolio of projects

THANK YOU FOR YOUR ATTENTION…