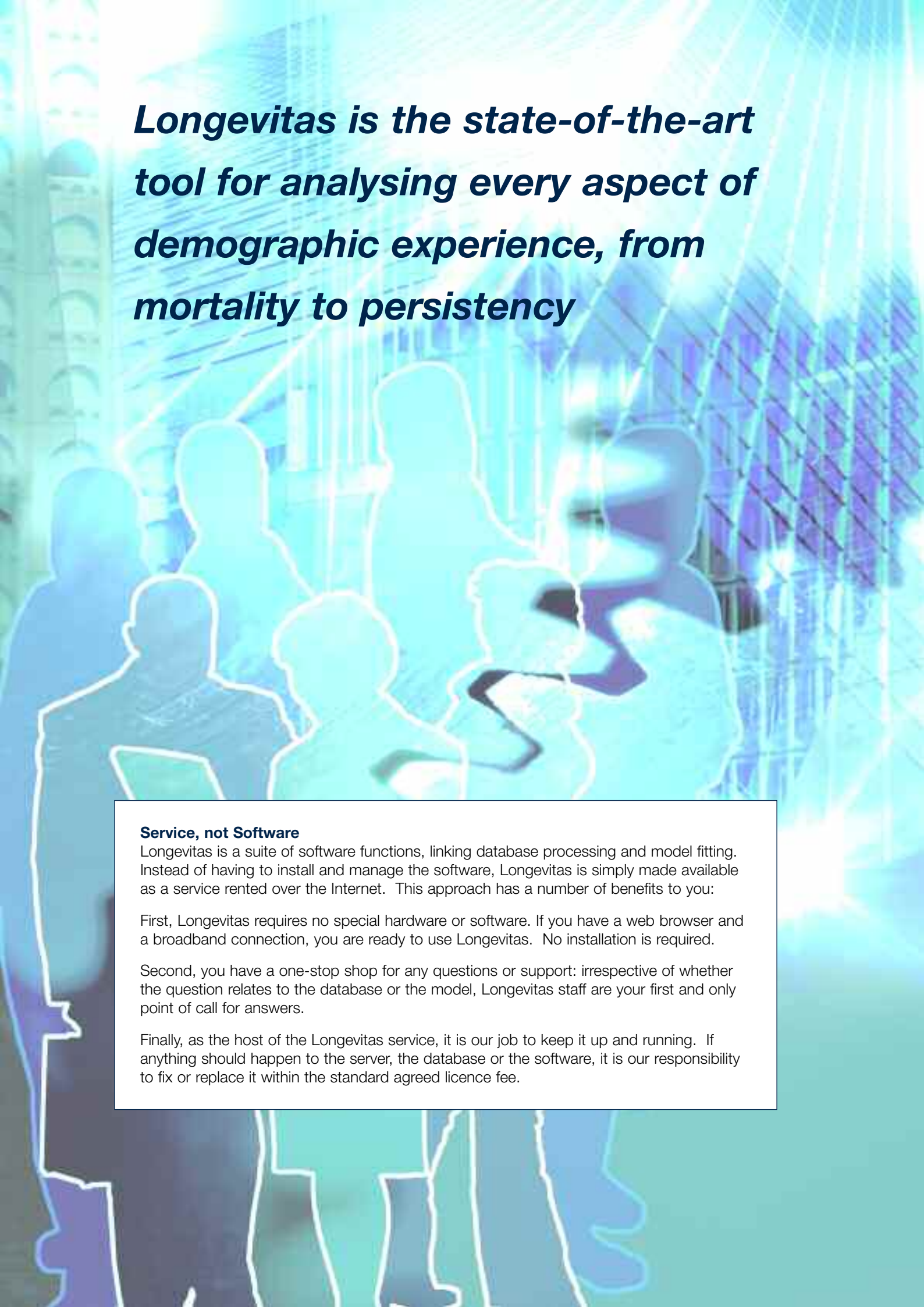


The background of the entire page is a light blue, semi-transparent image of a person's hands typing on a computer keyboard. A large, semi-transparent gear is overlaid on the right side of the image, partially covering the keyboard and the person's hand. The overall aesthetic is clean and professional, with a focus on technology and industry.

**Demographic risk management for
insurers and pension funds**



LONGEVITAS



Longevity is the state-of-the-art tool for analysing every aspect of demographic experience, from mortality to persistency

Service, not Software

Longevity is a suite of software functions, linking database processing and model fitting. Instead of having to install and manage the software, Longevity is simply made available as a service rented over the Internet. This approach has a number of benefits to you:

First, Longevity requires no special hardware or software. If you have a web browser and a broadband connection, you are ready to use Longevity. No installation is required.

Second, you have a one-stop shop for any questions or support: irrespective of whether the question relates to the database or the model, Longevity staff are your first and only point of call for answers.

Finally, as the host of the Longevity service, it is our job to keep it up and running. If anything should happen to the server, the database or the software, it is our responsibility to fix or replace it within the standard agreed licence fee.

Individual Lives, not Groups

Traditional actuarial analysis has focused on the experience of groups, e.g. males aged 60–64. When applying mathematical models, such as GLMs, this leads to the requirement for a minimum expected number of events (deaths) in a particular group. This can quickly lead to the need for very large volumes of data, or else to the over-simplification of a model simply because the number of expected events is not large enough for all groups.

Longevitas models mortality of the individual life, not of the group. This neatly side-steps the problem of a minimum number of expected events. It also enables the analysis of a limitless number of possible rating factors: if you have lots of information on each life, say in the form of underwriting questions, then you can use all this information. With Longevitas you never need to worry about having enough observations for each risk combination.



Automatic Data Preparation

One of the most overlooked areas of modelling mortality and other decrements is data preparation. This Cinderella task is, however, one of the most important: after all, one cannot build a mansion without a good foundation!

When you upload your data to Longevitas, it is first checked for basic validity. A report of all errors can be downloaded for inspection, or handing to a data-cleanup team. Invalid data is automatically filtered out from modelling work.

The next step is “de-duplication”, i.e. the removal of duplicate records. It is very common for people to have multiple benefit records, and it is important to merge these duplicate records before modelling. Longevitas has ten different schemes for identifying duplicates, depending on what data you have and how you want to match records. You can control which deduplication schemes are applied automatically, and which simply display potential groups for interactive browsing and merging as appropriate.

Socio-Economic Profiling

Socio-economic group is a very important predictor of all sorts of risk, including mortality. Whatever risk you are modelling, socio-economic group is likely to be one of the more significant factors.

Longevitas has a built-in profiler for socio-economic group, and profiling takes place automatically during data processing. Longevitas can be set up for automatic profiling in a variety of territories, including the UK, USA, Canada and the Netherlands. Profiling uses the full postcode in the case of the UK, Canada and the Netherlands, and the nine-digit zip code in the USA (also sometimes called “zip+4”).

Longevitas also offers you a choice of profiling systems, including Mosaic from Experian and Acorn from CACI. Other profiling systems are available on request: just ask us!

Regional Profiling

Most regional variation is due to different socio-economic mix. However, there is often still a residual regional effect after allowing for socio-economic group, and region can therefore be a useful modelling variable.

Longevitas has a built-in profiler for region, and profiling takes place automatically during data processing. Longevitas can be set up for automatic regional profiling in a variety of territories, including the UK, USA, Canada and the Netherlands.

Generalised Linear Models (GLMs)

GLMs have been shown to be useful for modelling annuitant and pensioner mortality – see Richards and Jones (2004). Many life companies have recently adopted GLMs for analysing their annuitant mortality.

Although we recommend survival models in preference to GLMs, Longevitas offers four different kinds of GLMs for life-insurance and pensioner data. Although many packages will fit GLMs, only Longevitas also offers integrated data preparation and factor-optimisation.

GLMs do have some important drawbacks, however, and we recommend you consider either survival models or geometric models as alternatives (both are available in Longevitas).



Survival Models

Survival models offer considerable advantages over GLMs, including the automatic modelling of mortality over multiple years, and the use of fractional years of exposure.

Longevitas offers three different kinds of survival models for life-insurance and pensioner data, based on the Cox model, together with the Gompertz and Makeham laws of mortality. Although other statistical packages will fit survival models, only Longevitas offers integrated data preparation and the ability to fit non-linear models.

Geometric Models

One drawback of GLMs for individual lives is the failure of the linearity assumption when modelling over multiple years: if q_x is linear after a suitable transformation, then ${}_2q_x$ and ${}_3q_x$ cannot be linear under the same transformation. For users of GLMs at the individual level, this means only being able to use one year's data, and the usual solution is to switch to survival models.

Now, however, Longevitas offers four kinds of GLMs as a *geometric model*. This enables you to extend your existing GLMs for multiple years' data, and provides a stepping stone from your existing GLMs to full survival modelling. The parameters in the model have exactly the same role, meaning and interpretation as your existing GLMs, but with the advantage of using more of your data and getting smaller confidence intervals as a result.

Projections

Longevitas has the ability to analyse time-based effects in your data, including:

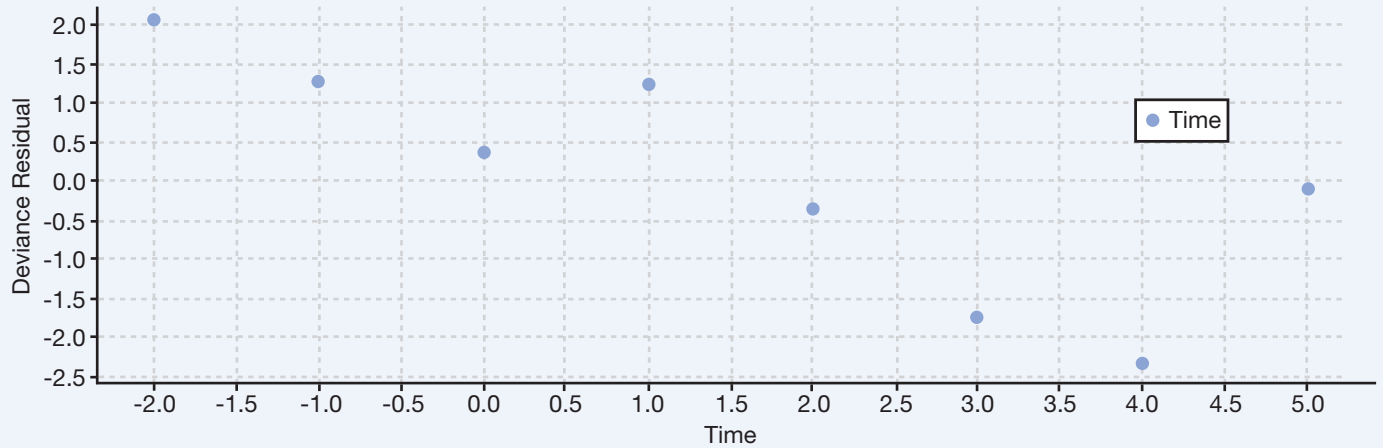
- Cohort effects
- Duration effects
- Time trend

A cohort effect is where risk is related to year of birth, i.e. beyond what simple age can tell you. A duration effect is where risk changes in relation to the time since observation, i.e. beyond what age or cohort can tell you.

Any model which includes one or more of these effects can also be used to do projections. If you use such a model to generate actuarial rate tables, then these tables will also include the projections.

Graph of residuals against age for the mortality of a portfolio of annuities. The downward pattern from left to right suggests that a time trend needs to be added to the model.

Plot: Deviance Residual against Time



Business Productivity

Longevitas will analyse your data better than any other package. But how do you make use of the results in your business?

First, all Longevitas models can be used to generate actuarial rate tables. Once you have a model you like, a single click will generate rate tables for use in spreadsheets, pricing tools or valuation systems. Longevitas generates rate tables in CSV format, so they can be easily uploaded into any system, including in Excel.

Second, a Longevitas model based on one portfolio can be used to profile or rate a second one. Thus, you can create a rating model based on your existing portfolio, and then use it to rate or price new business.

Third, all graphs and tables produced by Longevitas can be copied and pasted into Word and Excel. This allows you to use Longevitas's output directly in your own reports.

Graphs

Longevitas has a comprehensive graphing tool, which enables the plotting of:

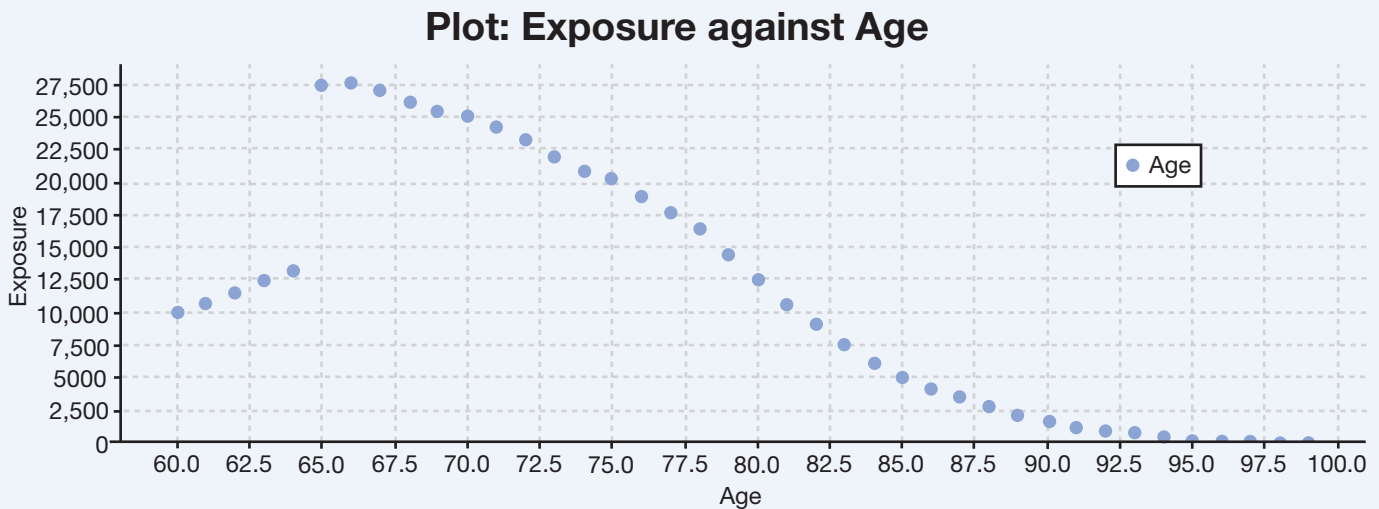
- Residuals
- Crude risk rates
- Events (deaths)
- Lives
- Exposures
- Actual events v. expected

Longevitas also allows you to freely choose your horizontal axis. All of the above can be plotted against age, duration or time. Longevitas also allows plotting separately for different sub-groups, e.g. for males and females, or different socio-economic groups.

If you want a special chart type not support by Longevitas, any data set can be copied from Longevitas into Excel to create your own charts.



Graph of exposure against age for a pension scheme. The step change at age 65 occurs because this is the scheme retirement age.



Expert System

Longevitas has a built-in help system: if there is a term you do not understand, simply move the mouse pointer over the help icon and help text will appear on screen where you need it.

Longevitas automatically performs statistical tests on each model fitted, including goodness of fit tests. The results of these tests are displayed, along with interpretations. Longevitas will also make comments about your models or data, and will even make recommendations where it thinks it recognises a common problem.

Factor Optimisation

It is often the case that you have a potentially useful rating factor which is simply too complicated for practical use. For example, there are 124 postcode districts in the United Kingdom, but you might just want a three-level factor for regional variation. Alternatively, you might have hundreds of product codes, but you might just want four broad groups of products. How do you find the optimal simpler groups?

Longevitas has a *factor optimiser*, which will find these simpler groupings for you. The optimiser will test every single possible combination of simplifying your complicated rating factor, *even if this means fitting thousands of models*. At the end of the process, you will be given the model results and the optimal mapping from the complicated factor to the simplified one. You can also download your original data set with the new optimal factors appended to each life. In fact, you can even generate a file with a bespoke mortality table for each and every life in the portfolio.

Multiple Decrements

Longevitas can handle unlimited simultaneous decrements, making it ideal for complex multiple risks. Thus, you can use Longevitas to handle competing risks such as mortality, critical illness and lapse.

Parallel Processing

Longevitas's modelling core is hand-written in C++. As a result, Longevitas has been designed to take advantage of the new trend towards servers having multiple cores. Complicated tasks can be split into separate streams of work and then processed in parallel simultaneously. The result is a dramatic reduction in the time taken to perform certain tasks, especially factor optimisation.

Security

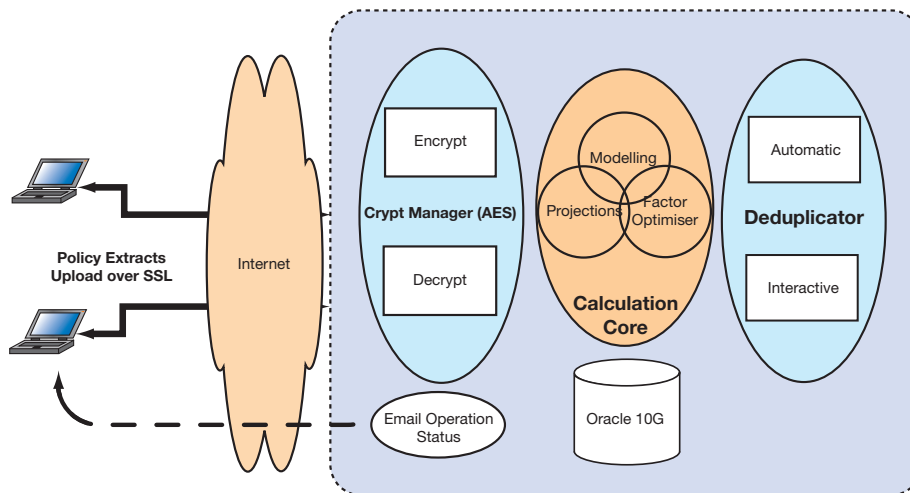
Longevitas stores all personally identifiable data in encrypted form, with decryption only possible using keys unique to each user. Uploaded files travel over SSL (Secure Sockets) and are not written to disk until they are encrypted using the NIST's Advanced Encryption Standard (AES), a strong cryptographic cipher that was the product of a five-year selection and testing process. There are to date no known feasible attack on this cipher.

Identifiable data written into the Oracle database is also encrypted using AES, and keys are stored multiply encrypted so even open access to the database files would be insufficient to expose private data. The application is deployed on RedHat Enterprise 4 incorporating the SELinux security hardened kernel, and the servers itself are protected behind well-maintained firewalls.

All Longevitas servers incorporate hardware resilience features such as hot-pluggable hard-drives, RAID filesystems, redundant power supplies, and are housed at Scolocate, one of the UK's premiere co-location data-centres.

Technology

Longevitas consists of an Enterprise Java Web application surrounding a highly optimised C++ calculation core. C++ was chosen to provide the fastest possible calculation throughput for handling the largest annuity portfolios. Data preparation and filtration is performed against the industry-standard Oracle 10G Database.



Audit

It is a fact of modern business life that one must demonstrate a clear trail of evidence from data to decision. Longevitas records every single user operation, and all output is stored. It is impossible for a user to delete any report or the results of any model. Backups take place nightly and are held off-site.

Longevitas also has the facility for an entire model summary to be generated as a PDF file, complete with graphs, comments and recommendations. This PDF can be stored outside Longevitas, including for sharing with auditors or business partners.



mortalityrating.com is a service for companies with defined-benefit pension plans in the United Kingdom. It recommends a mortality basis for pensions in payment using a proprietary model driven by postcode. The socio-economic and regional groupings which lie behind mortalityrating.com were created using Longevitas.

Demographic risk management for insurers and pension funds

References

Richards, S. J. and Jones, G. L. **2004** *Financial aspects of longevity risk*, Staple Inn Actuarial Society, London

Richards, S.J., Ellam, J. R., Hubbard, J., Lu, J. L. C., Makin, S. J. and Miler, K. A. **2007** *Two-dimensional mortality data: patterns and projections*, paper presented to sessional meeting of Faculty of Actuaries on 19th March 2007

Contact

More information, including case studies, latest features and technical documentation, can be found on our website at www.longevity.co.uk

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